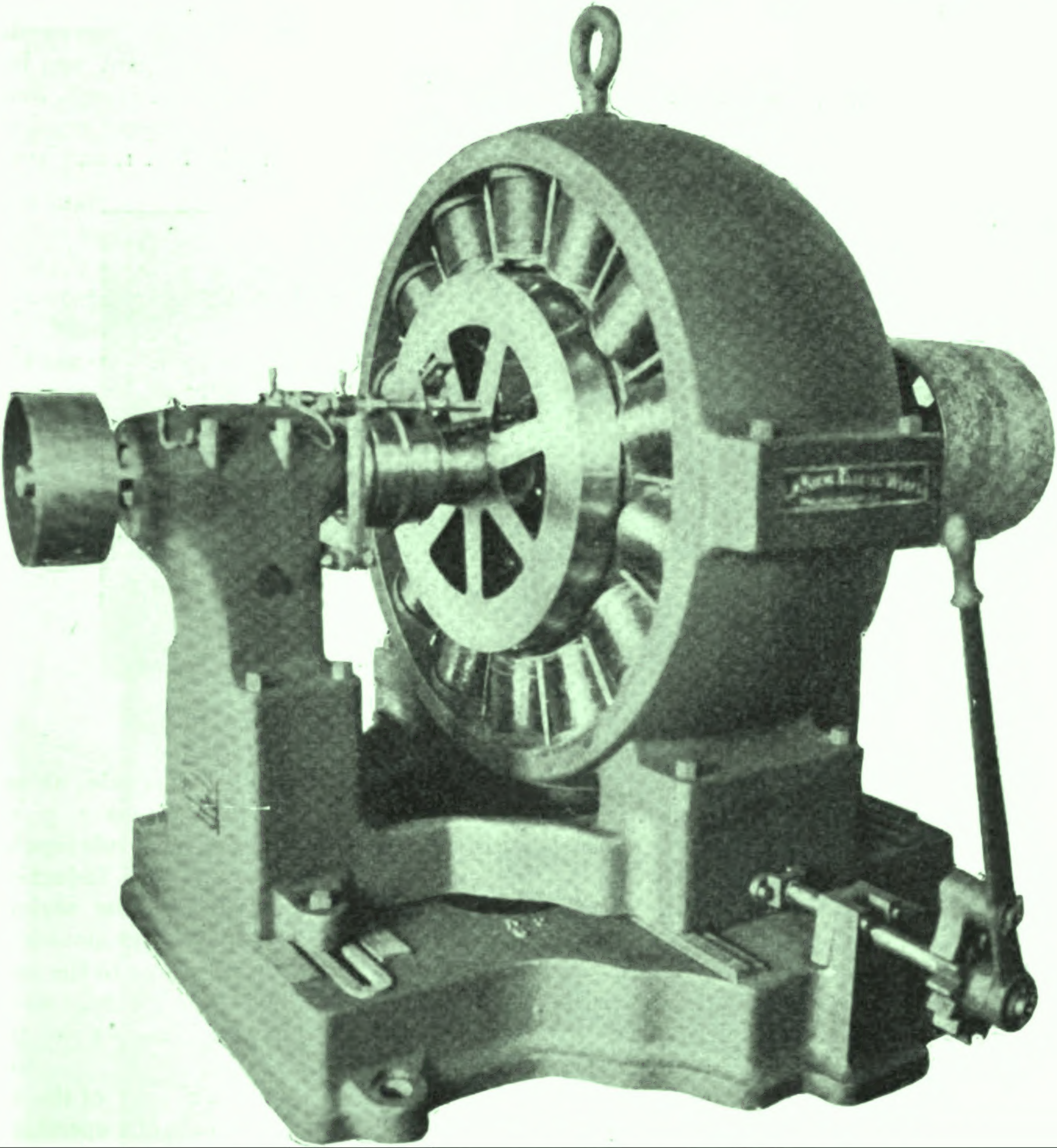

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AN ELECTRIC YACHT.

IT has been the misfortune of the storage battery that Lord Kelvin's sensational and theatrical introduction of the Faure cell to the public led to electric storage becoming the favorite theme of the freak newspaper writer, and excited in the minds of the non-technical the most unbounded expectations as to its possibilities. Marine propulsion was one of the favorite presumptive applications, and most enticing hopes were held out as to the revolution the storage battery would work in the conduct of ocean travel. As years went by and it was found that the great promises were not realized, the inevitable reaction followed and electric storage received the cold shoulder from every side.

Though one of the earliest applications of the storage battery was to the propulsion of small boats, the Seine and Thames having been the scene of operation, the disfavor referred to resulted in a cessation of effort in this direction until the fleet of electric launches at the World's Fair caused a renewal of interest. At the present time, the electric launch industry is a growing one, being founded upon a basis that recognizes its limitations, and is therefore not apt to again come into disrepute.

The most extensive application yet made of electric storage boat propulsion is in the electric yacht "Utopian," designed by Mr. Charles D. Mosher and launched last fall from Ayre's ship yard at Nyack-on-the-Hudson. The yacht is the property of Mr. John Jacob Astor, who is an enthusiast in whatever pertains to electricity.

The "Utopian" is 72 ft. over all, 12 ft. beam, and has a draft of 4 ft. Mr. Mosher has introduced some original features into the design of the hull. There is a channel-way for each of the twin propellers, so arranged that the screws always work in solid water, which provision is quite necessary when it is considered that the screws at full speed revolve at the rate of 1200 r.p.m. The stern is also peculiarly shaped with this object in view. Below the water line the shape is much like that of a scow. Above the water line the curves are given a graceful shape that suggests former types. The combination causes the boat to have rather an odd appearance in dry dock, the stern having a peculiar heel shape. This is said to be the very latest improvement in the design of high-speed screw-driven yachts. The arrangement makes it difficult to clear the propellers when they become entangled with weeds, and as the boat is to cruise largely in inland waters, this might constitute an objection, but in other respects this form is said to be highly desirable. The boat is fitted with two center-boards of Tobin bronze, which may be raised or lowered by electric winches from the promenade deck. It has also an electric capstan and an air pump run by electric power which compresses air to a pressure of 150 lbs. per square inch to blow the boat's whistle. The capstan motor is of one-kilowatt capacity, geared to the capstan in the ratio of 60 to 1; the same motor also runs the air pump above referred to. The boat is supplied with an elaborate electric signalling system. The owner or captain has at his service, both from the bridge and below, 14 push buttons connecting with an annunciator in the galley aud other quarters

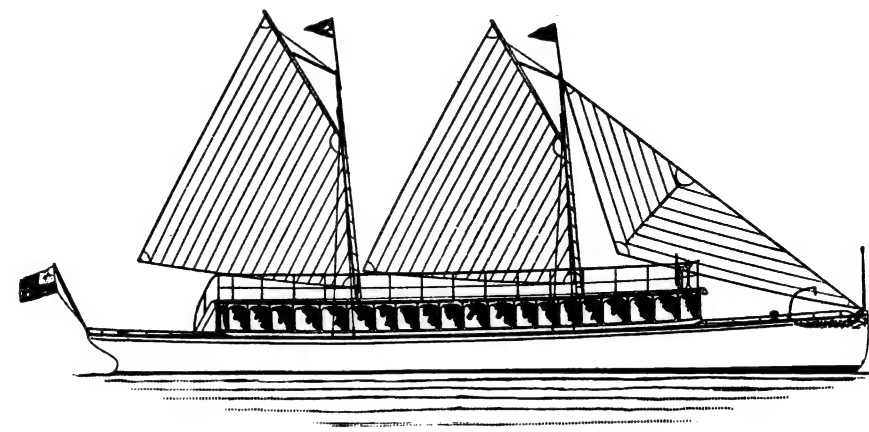
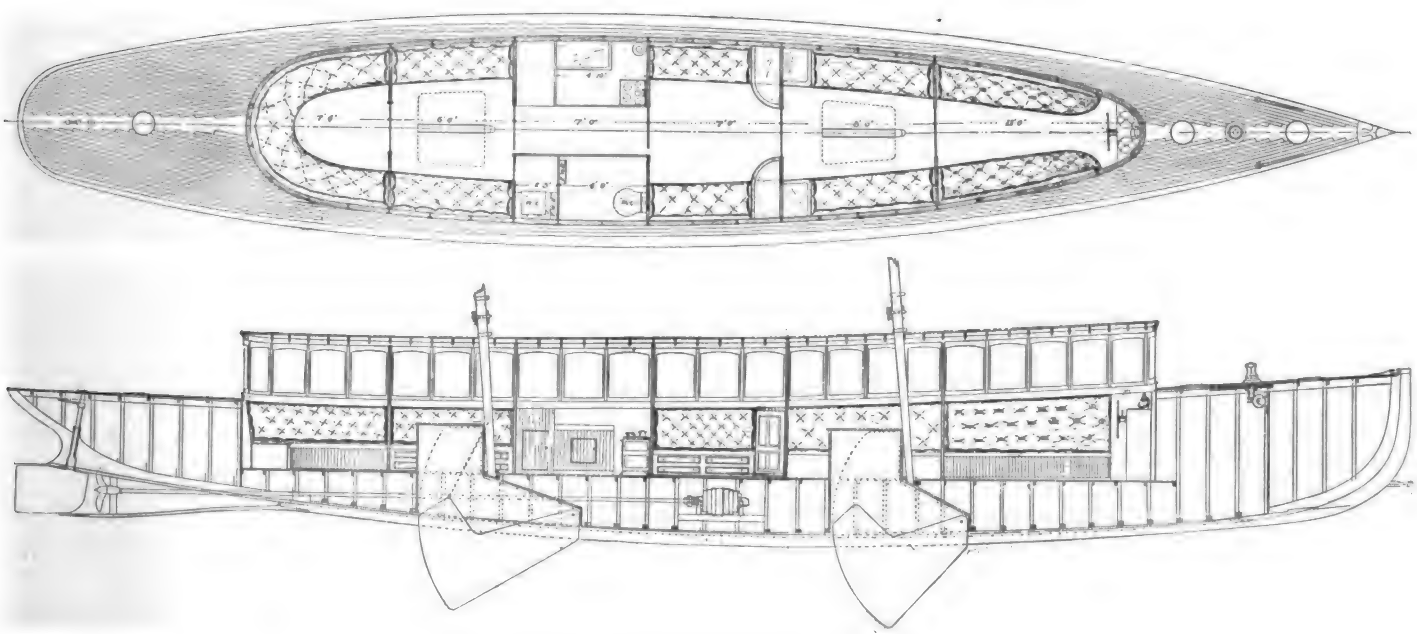


FIG. 1.—ELECTRIC YACHT "UTOPIAN."



FIGS. 2 AND 3.—ELECTRIC YACHT "UTOPIAN."

of the boat, this giving him at all times entire control of the yacht.

In the construction of the boat no expense has been spared, the decks, planking and exterior finish being of polished mahogany, except the gunwales, which are of quartered oak. A low brass railing is worked around the deck at each end, and all of the various deck fittings are of polished bronze.

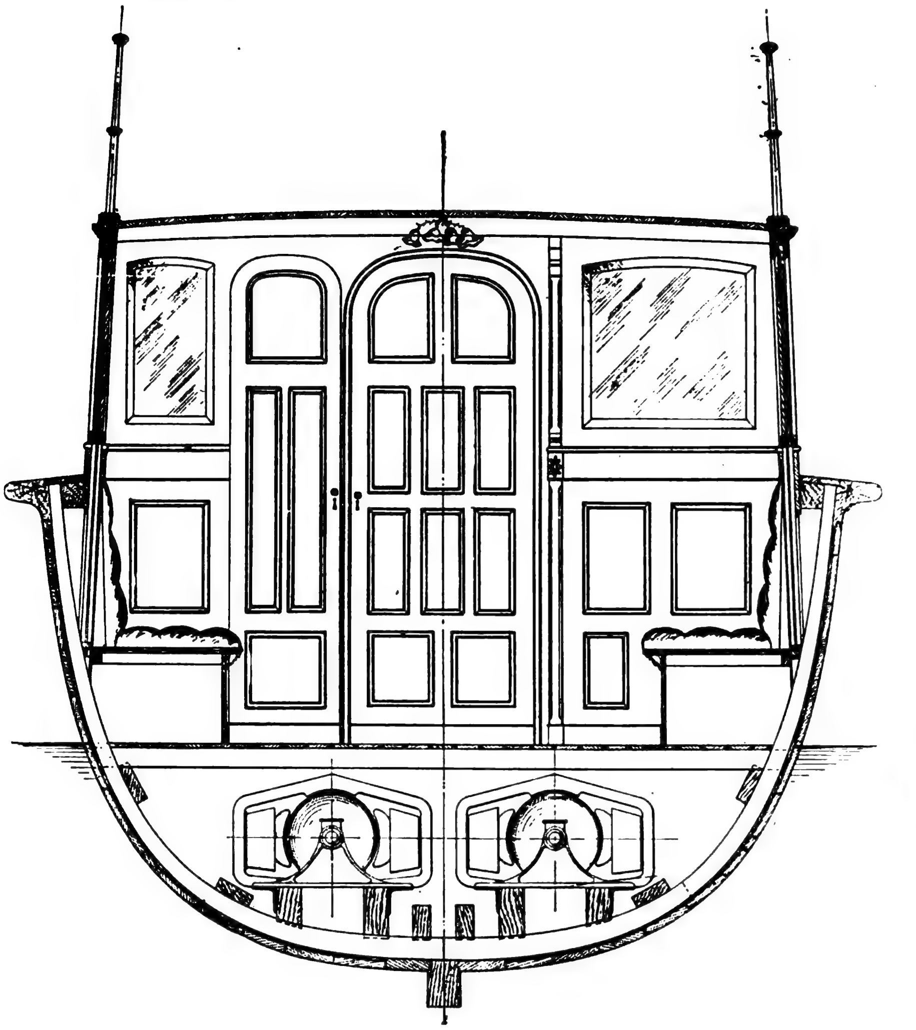


FIG. 4.—MIDSHIP SECTION OF ASTOR YACHT "UTOPIAN," SHOWING MOTORS.

Figs. 2 and 3 give an idea of the arrangement of quarters. Forward there is a cockpit 11 ft. long, with windows and seat transoms on each side, the forward windows being fitted with bent glass. In this compartment are a preventer steering wheel and motor controllers, as well as the usual ship working equipment of compasses, speaking tubes and signal fittings. A second controlling station is provided on the hurricane deck. The spindles on which the hand wheels in the forward cockpit are attached extend upward through the hurricane deck, and are provided at their ends with a second set of hand wheels. This, together with the devices for controlling the search light and steering the boat, make as complete a controlling station on the hurricane deck as in the forward cockpit, a convenience that will be appreciated in warm weather, when this boat will probably be most used. All of the woodwork of the cockpit is in mahogany, and the seats are upholstered in leather.

FIG. 5.—SEARCH LIGHT LAMP.

Abaft the cockpit is the saloon, which is 8 ft. long and the full width of the boat. The seats on either side are arranged to fold out and form wide berths. Under the seats are drawers, and at the after ends of the saloon on each side are buffets. The saloon is also supplied with a folding table.

Next abaft the main saloon are the owner's quarters, 7 ft. long and the full width of the boat, fitted with seats on either side, so arranged to be used as berths, and with buffets at the forward end. Abaft of the main saloon on the port side is a galley fitted with ice chest, sink, French range, dish racks, closets, etc., while on the starboard side is the owner's toilet, with all modern accommodations. Abaft of these are the crew's quarters, 6 ft. 6 ins. long, extending the full width of the boat, and fitted with seats, folding berths, with lockers and drawers underneath, and a folding table. Abaft the crew's quarters is the after cockpit, 7 ft. 7 ins. long, the seats of which are upholstered in leather.

The boat is also provided with sail power, being rigged as a two-masted schooner. The masts are hinged so that they may be lowered when desired. As shown in Fig. 1, the sails consist of a jib, foresail and mainsail. The lighting of the boat, of course, is electric. The bulbs of the incandescent lamps have the shape of an oblate spheroid. Three wires are sealed into their edges. Two of these form conducting wires and the third is merely a support. The lamp is suspended horizontally by three platinoid springs in the focus of a spherical reflector, and covered with a crystal on which is etched the initials J. J. A. The ceilings are studded with these lamps and their illumination is very pleasing. On the hurricane deck is a Rushmore 1200-CP search light which can be operated both from the deck and from below.

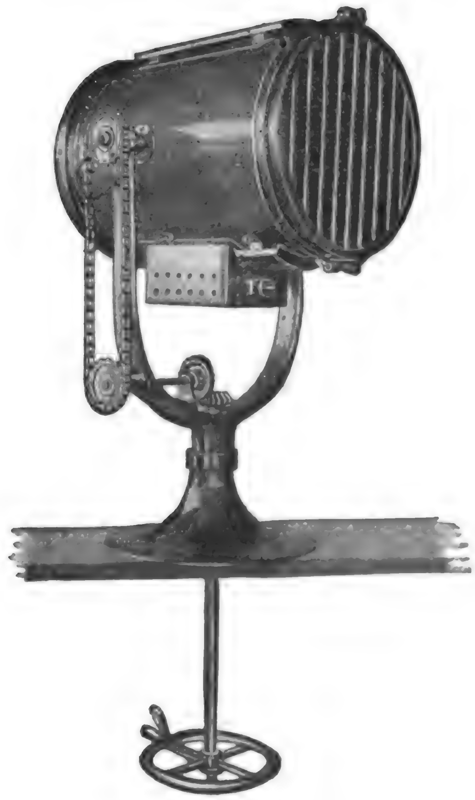


FIG. 6.—SEARCH LIGHT.

The search light, which is shown in Fig. 6, is 10 ins. in diameter and ordinarily takes 6 amperes at 50 volts, though it can be worked at 8 and 10 amperes. The light is thrown in a clear solid stream without spreading and will show a buoy at night ½ mile distant. The lamp carries the carbons in a horizontal direction, as shown in Fig. 5; it contains no screw rods or contact devices and is operated by a single electromagnet.

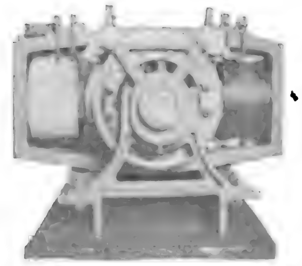


FIG. 7.—PROPELLER MOTOR.

The twin screws of the boat are 30 ins. in

meter and have three blades each; they are designed to drive the boat at a maximum speed of 16 miles per hour, corresponding to 1200 r. p. m. Each screw shaft is direct-connected to the armature of a Riker 25-KW motor situated underneath the floor of the main saloon.

The motors weigh only 1168 lbs. each, and have a guaranteed efficiency of eighty-five per cent. at full load, and will withstand an overload of 100 per cent. for four hours. The armature is of the hollow drum type with a wave winding, the coils being form-wound; the brushes, which are of carbon, are 90 degs. apart, and the commutator, as will be seen from Fig. 7, is of most generous size. The entire electrical equipment, including battery, weighs but little more than 12 tons.

The fields are of steel, and have four poles; two of these have windings, and the other

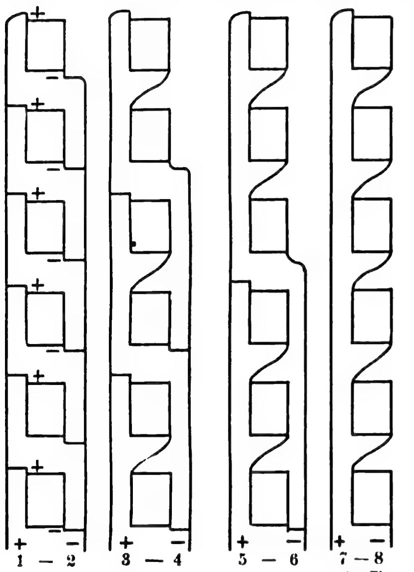


FIG. 8.

two are consequent poles. The motors at full load take 125 amperes each at 200 volts, driving the screw at 1200 r. p. m. The fields are in series with the armature and so arranged that the two bobbins may be thrown either in parallel or in series. The fields and groups of cells are capable of being arranged in eight different combinations by means of controllers very similar to an electric railway controller, being cylindrical in shape, and worked by a geared hand wheel. The controllers which, as well as the entire electrical equipment aside from the batteries, were furnished by Mr. Andrew L. Riker, are in duplicate, one being located on the hurricane deck and the other in the forward cockpit.

The storage batteries are of a new system having no grid plates, and were furnished by the Samuels Dynamic Accumulator Company, of New York. The positive plate is solid, very hard and dense, and is said to improve in its durable qualities with use. Each cell has 11 plates weighing 26 lbs., the cell complete with electrolyte being claimed to weigh only 50 lbs.

Each screw has its own controller and battery, the latter being of 300 ampere-hours capacity, and consisting of 204 cells. The cells are divided into six independent groups of 17 pairs of cells each—each pair being in parallel and the 17 pairs in series, this giving 34 volts for each group.

The six groups by means of the controller can be thrown into four different combinations, as illustrated in Fig. 8. As the motor fields may either be in series or parallel, this gives eight different speeds for the propellers.

Referring to Fig. 8, the first combination is of the six groups in parallel, giving a voltage of 34; with the fields in series the slowest speed is attained, which is increased when the fields are thrown in parallel. In combinations 3 and 4, the groups are arranged three in parallel, giving a voltage of 68, and two different speeds corresponding to the series and parallel grouping of the fields. In combinations 5 and 6, the groups are in parallel by pairs, giving a voltage of 102, and in the remaining combination,—7 and 8—all are in series with a voltage of 204. The first four combinations are employed both for backing and ahead, and the latter four for ahead alone.

METHOD OF MEASURING THE EFFICIENCY OF A SHUNT MOTOR WITHOUT A DYNAMOMETER.

BY PROF. A. F. MCKISSICK.

The following method is practically the same as Swinburne's method for measuring the efficiency of a dynamo without a dynamometer, and is sufficiently accurate for all commercial purposes.

The method consists in measuring the watts supplied to, and the watts lost in, the motor. The difference between these amounts is the watts utilized, and this difference divided by the watts supplied is the commercial efficiency of the motor at the given load.

As an example, suppose it is desired to test a motor carrying a load, the potential of supply being 110 volts and the motor of about 10-HP capacity.

Measure the voltage of supply at the motor terminals (110 volts), the amperes supplied to motor, say, 75, the speed per minute, say, 1600, and the current flowing in the shunt fields, say, 5 amperes—these measurements being taken with motor loaded. Now remove the belt and measure the resistance of the armature by means of a testing set or by means of the voltmeter and ammeter method (sending a current through the armature at rest and measuring the potential difference at armature terminals, the armature resistance being equal to the potential difference divided by the current flowing in armature). Assume this resistance to be .02 ohms.

With the belt removed, run the motor at no load and so adjust the starting box that we get a speed of 1600. If all the resistance in the starting box is cut out, we will get a higher speed, so some resistance must be left in to get the desired speed. Measure the current supplied, say, 11 amperes, the voltage at terminals, 110, and also the potential difference between the terminals of the starting box, say, 15 volts.

The watts lost in a motor are due to (1) hysteresis, (2) eddy currents, (3) friction, (4) heat loss in the field circuit, and (5) heat loss in the armature circuit. The first four losses in the example we have taken are practically the same at full load as at no load, since the field is of constant strength, and we made the speed constant by adjusting the starting box at no load.

The watts supplied to the motor at no load can be found by multiplying the current supplied (11 amperes) by the voltage (110), which equal 1210 watts. But because we have some resistance left in the starting box we have a loss in it of $(11-5)\times 15=90$ watts. Since 5 amperes go through the field, we have only 6 flowing through the starting box and armature. The loss in the armature $=6^2\times .02=.72$ watts, which can be neglected in comparison with 1210 watts. Subtracting the loss in the starting box (90 watts) from the total loss (1210 watts) we have 1120 watts as the amount lost due to hysteresis, eddy currents, friction and heat loss in the field.

At full load the total loss would be this amount (1120 watts) plus the amount lost in the armature. Since we have 75 amperes flowing, 70 will go through the armature (5 amperes through the field), and we have for the armature loss $(70)^2\times .02=98$ watts, making the total loss at full load 1218 watts. Our watts supplied $=110\times 75=8250$; therefore, the watts utilized $=8250-1218=7032$, or the commercial efficiency $=\frac{7032}{8250}=85$ per cent.

Electricians at Dinner.

The successful inauguration of electrical transmission of power from Niagara to Buffalo was celebrated at the latter city on Jan. 12, by a banquet given at the Pequod Club. About four hundred invited guests were present, among whom were Nikola Tesla, Prof. Elihu Thomson, Prof. E. J. Houston, Prof. Elisha Gray, Charles F. Brush, President Frederick A. Nichols of the National Electric Light Association, President Louis Duncan of the American Institute of Electrical Engineers, Dr. Coleman Sellers, George Westinghouse, Jr., C. A. Coffin, E. A. Adams, J. E. Hudson, S. E. Barton and a number of other prominent representatives of the commercial side of the electrical industry. Francis Lynde Stetson acted as toastmaster. The toast "The Company" was responded to by Mr. Stetson himself; "Welcome to Buffalo" by Mayor Jewett; "The Empire State" by Controller Roberts; "Electricity" by Nikola Tesla; "The City of Buffalo" by Charles W. Goodyear and "Water Power" by Charles A. Pillsbury, of Minneapolis. The general trend of the speeches was admiration of the Buffalo-Niagara transmission achievement which, some of the speakers considered, might justly be regarded as one of the triumphs of the century.

The Buffalo-Niagara Transmission.

In the article under the above caption in the December issue, the lightning arresters described were erroneously designated as the "Wurt lightning arresters." They were designed by Mr. H. C. Wirt, chief engineer of the supply department of the General Electric Company, which company installed the entire electrical plant at both ends of the line.

MECHANICAL STOKERS AND SHAKING GRATE BARS.

Although mechanical stoking is very old in England, it has not been until within the last ten years that it has received serious attention in this country. The greater demand for economy due to the gradual reduction of the margin of profit in nearly all manufacturing lines, has stimulated the production of coal and labor saving devices, and gradually mechanical stokers have passed from the condition of rarely used special appliances to that of well established articles whose use is considered essential in high class steam plants. This is particularly true in certain sections of the country where soft coal is exclusively used and in the centers where large manufacturing interests are concentrated.

The most rapid growth of the stoker industry dates from about 1888, and at present thousands of boilers are thus equipped. During this period the improvements have kept pace with the demands, until the most progressive work in such lines takes rank with other improved machinery and leaves but little more to be desired; in fact, the mechanical stoker has reached a point in development where it has not seemed to be capable of much further improvement along the lines now adopted, and is a substantially built, good, efficient working machine, warranting by its every-day performance the preference it has honestly gained as a valuable adjunct to power plants.

In a recent paper read before the American Society of Mechanical Engineers, Mr. Jay M. Whitam gives the following recognized advantages of mechanical stokers:

Adaptability to the burning of the cheapest grades or fuel; a saving of 40 per cent. of labor in plants of 500 HP or more when supplemented with coal handling machinery; economy of combustion, even under forced firing, with proper management; constancy and uniformity of furnace conditions, the fire being clean at all times and responding to sudden demands made for power, thus prolonging the life of boilers. The disadvantages enumerated relate to high first cost and expenditures necessitated for repairs, and to the skill required in operating stokers.

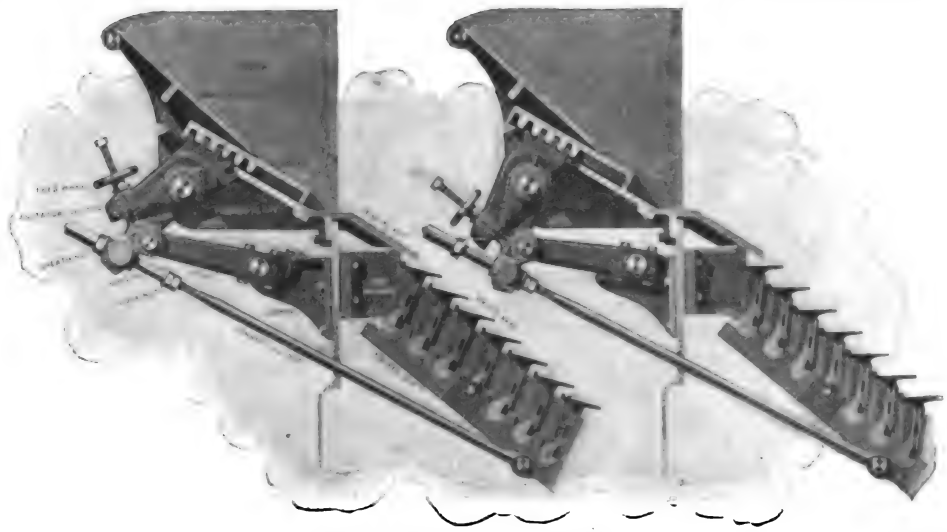


FIG. 2.—RONEY STOKER.

The items relating to first cost and repairs, which Mr. Whitam enumerates, can scarcely be classed as disadvantages if the use of mechanical stokers is in the end economical, all factors being considered. As to skill, the condition is not different from that which obtains when advantage is taken of labor saving devices in general, whose profitable adoption usually implies a greater skill in their operation than was necessary with the cruder methods thereby displaced.

Another objection sometimes urged against mechanical stokers is that they cannot be forced. The limitation in this respect is neither greater nor less than with natural draft in the case of ordinary hand-fired furnaces. Where forced draft is employed, the mechanical stoker is ideally applicable, obviating the losses incident to attempts at forcing under hand firing.

Another advantage of mechanical stokers that in some cases may be more important than any of those referred to above, is its smoke preventive quality. The question of smoke-prevention is one which, in some localities, may almost any day take on a serious import to manufacturers, and the mechanical stoker is the only practical solution that up to the present has been offered to that problem.

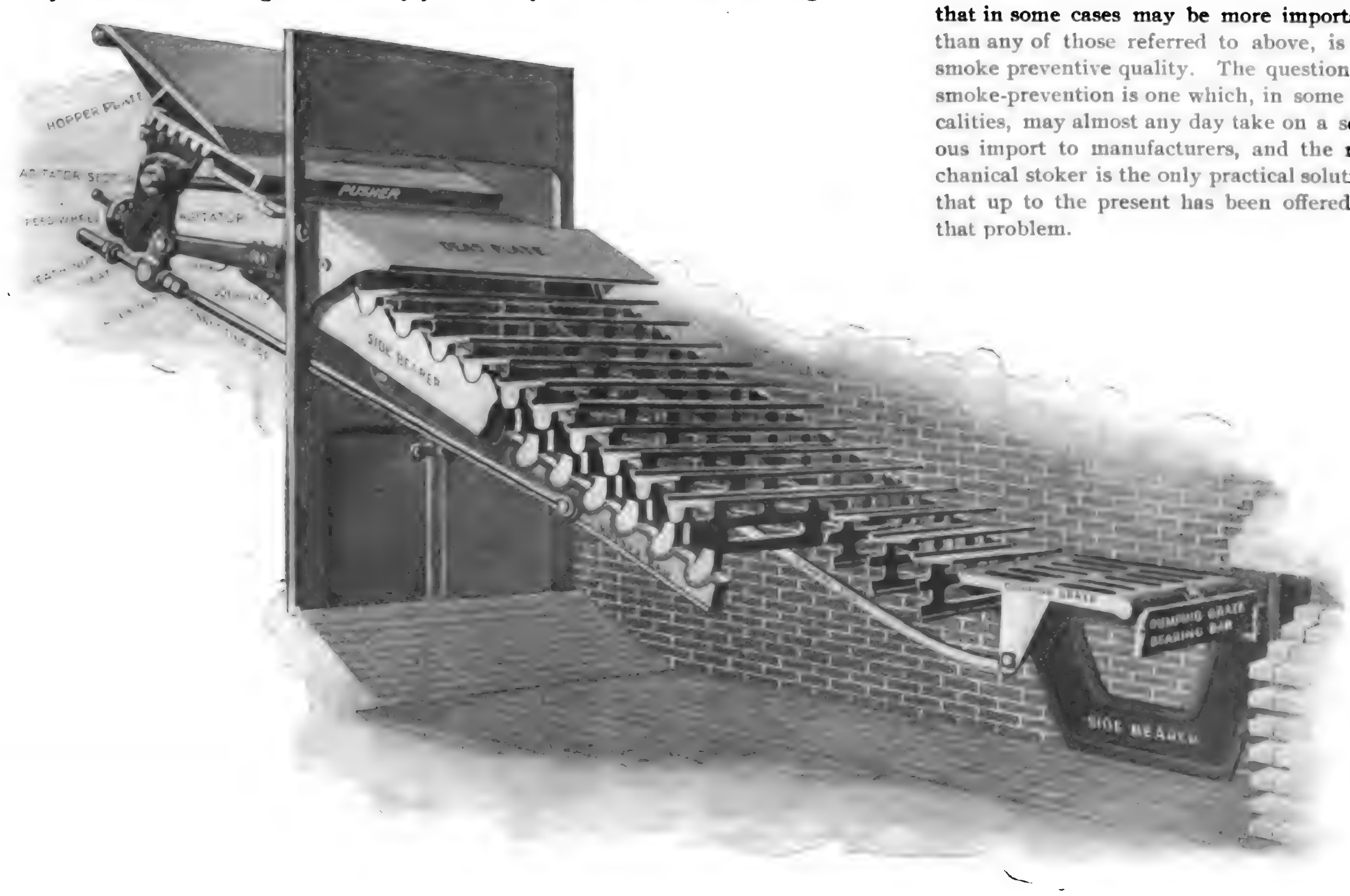


FIG. 1.—RONEY STOKER.

In addition to the descriptions of the several types of mechanical stokers now manufactured in this country, the principal forms

of shaking and dumping grates are also illustrated and described in this article. As the advantages involved in the use of such grates are so thoroughly recognized, it would be needless to here enumerate them.

There are two principal types of mechanical stokers—that in which the grates are inclined, under which come the Roney, Wilkinson, Murphy and Brightman stokers; and that in which the grates are horizontal, or nearly so, which includes the Babcock & Wilcox, Playford, American and Crowe stokers.

The Roney mechanical stoker is illustrated in Figs. 1 and 2. Referring to Fig. 1, the coal hopper receives the fuel and by means of a pusher feeds it onto a dead plate, which in turn delivers it to the bars. The coal is then slowly propelled down the flat stepped bars by their slight rocking motion, which is adjustable by means of the nuts at the outer end of the connecting rod. The first combustion occurs slowly near the top under a coking arch, and increases in intensity downward nearly to the dumping grate, onto which the ashes and cinders are fed by the bar motion. The mechanism by which the pusher, feeding the coal, receives motion from a slow-running shaft across the boiler front, and the means of adjustment to secure any rate of feed are so simple and so evident in the illustrations (Figs. 1 and 2) that special description is unnecessary. The transverse stepped bars have depending webs containing long slots, through which the entire under surface of the fire can be seen, and between which slice bars can be used when necessary to assist in loosening clinkers, without opening the fire doors or materially disturbing the fire bed.

The bars rest on trunnions fitting into side bearers, and are connected by a rocker bar engaging lugs depending from each bar, so that the entire set may rock together. In their motion they rock forward, as shown in Fig. 2, until they form a steep incline favoring the descent of the coal, and then rock back to the stepped position as shown, thus breaking up the fire bed and admitting an ample supply of air. The motion is scarcely perceptible, being from seven to ten strokes per minute.

The dumping grate is in two parts, so that each half may be dumped separately. By releasing the dumping rod the grate drops and throws into the ash pit its full charge of ashes and clinkers, and upon returning to position it is quickly covered with ash and burning coal by the downward feed. If the dumping rod is only partly released and the grate partly dropped and brought back with a fling, only part of its contents are discharged and it remains covered with ash. It will be observed that in this design practically all of the mechanism is out of the furnace, and no close fits are required. The

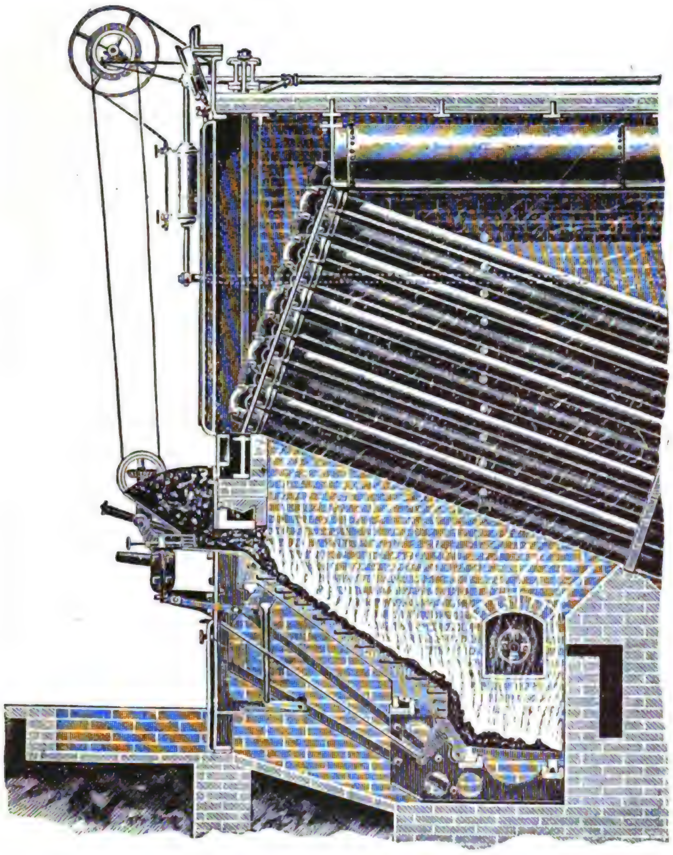


FIG. 6.—BRIGHTMAN STOKER.

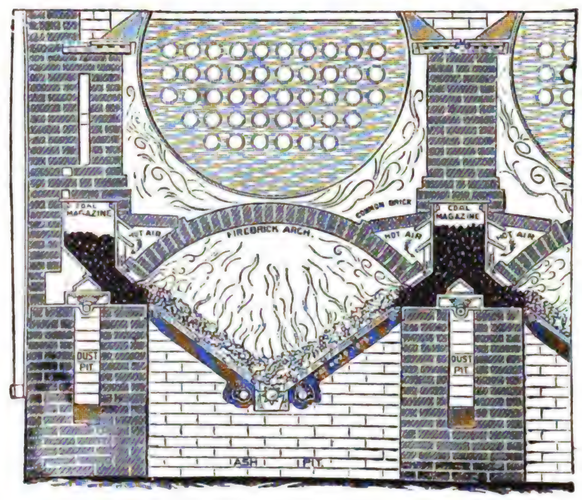
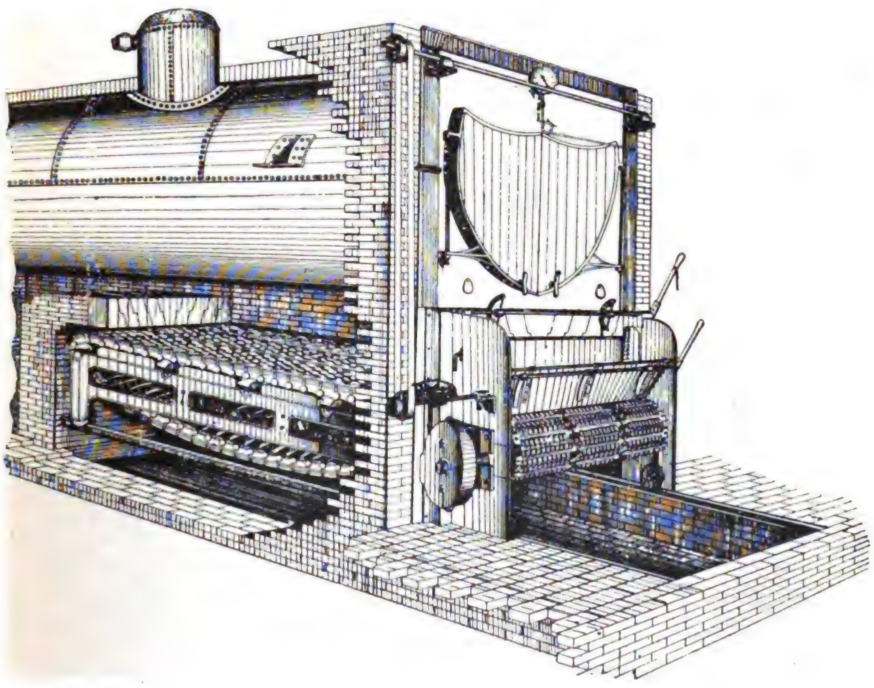
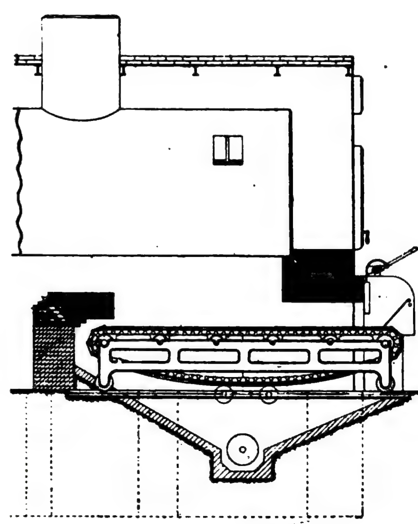


FIG. 7.—MURPHY STOKER.





FIGS. 4 AND 5.—PLAYFORD STOKER.

bars merely rest on trunnions and are some distance apart, thus preventing moderate warping from interfering with their action. The way in which they shelve over each other permits of a considerable distance between them even with fine coal, slack, etc. The ash pit is large and roomy, and the boiler front cool. The bars being transverse are exposed to equal temperature throughout their length, and as they gradually wear out with use or burn, certain whole bars suffer and not one end of each bar. Renewals are usually confined to four or five bars in the hottest part of the furnace. The bars are in two parts, the web or main body carrying the trunnions, and the removable top which is exposed to the fire. The tops only are renewed as required and constitute less than one-third of the weight of the bar.

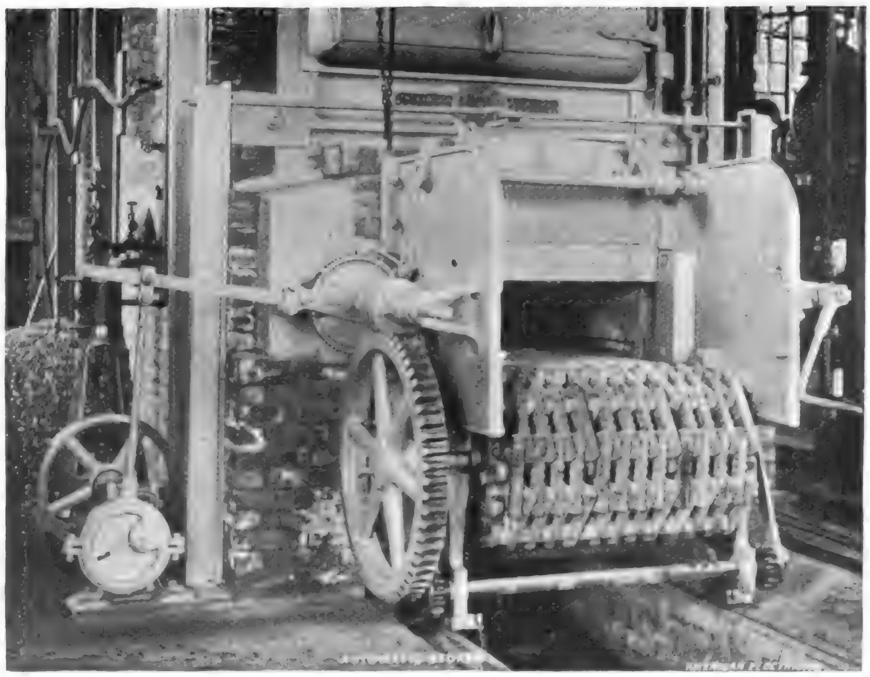


FIG. 9.—BABCOCK & WILCOX STOKER.

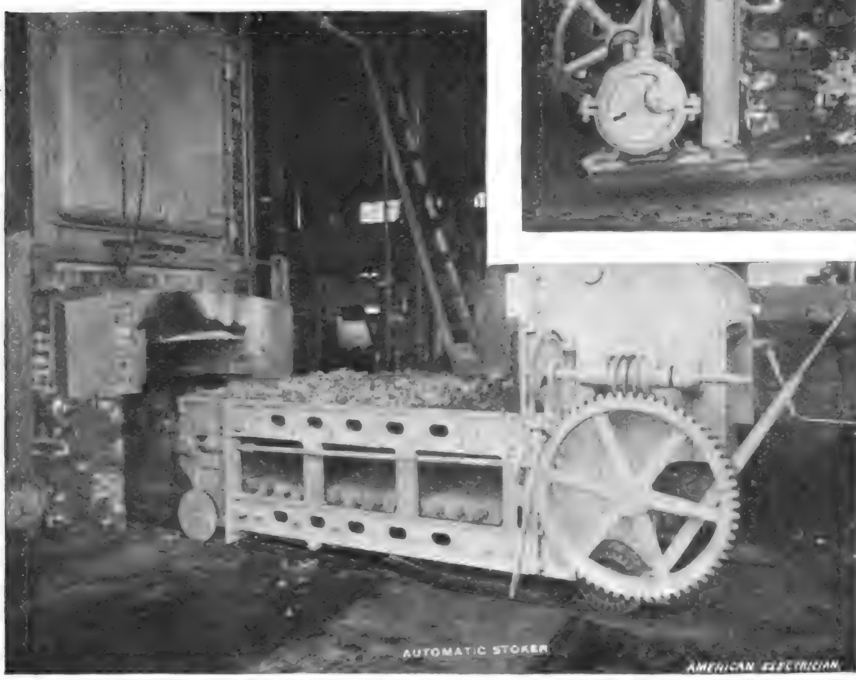


FIG. 8.—BABCOCK & WILCOX STOKER.

The Wilkinson mechanical stoker, shown in Fig. 3, uses steam jets to force into the fire the air needed for combustion.

The grate bars are a series of hollow castings, approximately of rectangular cross section, placed side by side, and inclined toward the bottom of the furnace at an angle suited to the repose of the fuel. The upper end (open to admit the blast pipe) projects through and is supported by the stoker front; the lower end slides on and is supported by the bearer bar, as shown. Throughout the inclined length and on the face of the bar is cast a succession of steps; through the rise of each step a vent of proper proportions is provided to admit air through the fire to the combustion chamber.

The pusher shown at the bottom of the hopper, and resting on the grate bars, is secured to each alternate bar by a dowel pin, and moves with them, feeding the fuel in measured quantities from the hopper to the other end of the grate; the continuous reciprocating motion of the grate bars thereafter insures uniform thickness of fire. There is a slow but gradual advance of the remaining fuel to the bottom of the grate, where the ash is deposited in the stationary grate, shown projecting from the bearer bar. The accumulated ash is pushed off this stationary grate into the pit by the reciprocating motion of the bars, from which it is removed in the usual manner or by special appliance.

The mechanism for effecting the operation of the stoker consists of a pulley, compound gearing, toggle shaft and quadrant. Steam jets at the upper end of each bar give rise to an induced current of air, which enters the fire through a vent in the rise of each step.

The Playford mechanical stoker, shown in Figs. 4 and 5, consists of an endless revolving chain of grate bars, which supply a steady continuous charge of fuel. The grate bars are short, thus overcoming warpage. The carriage supporting the bars is strongly bridged and trussed, and is not exposed to

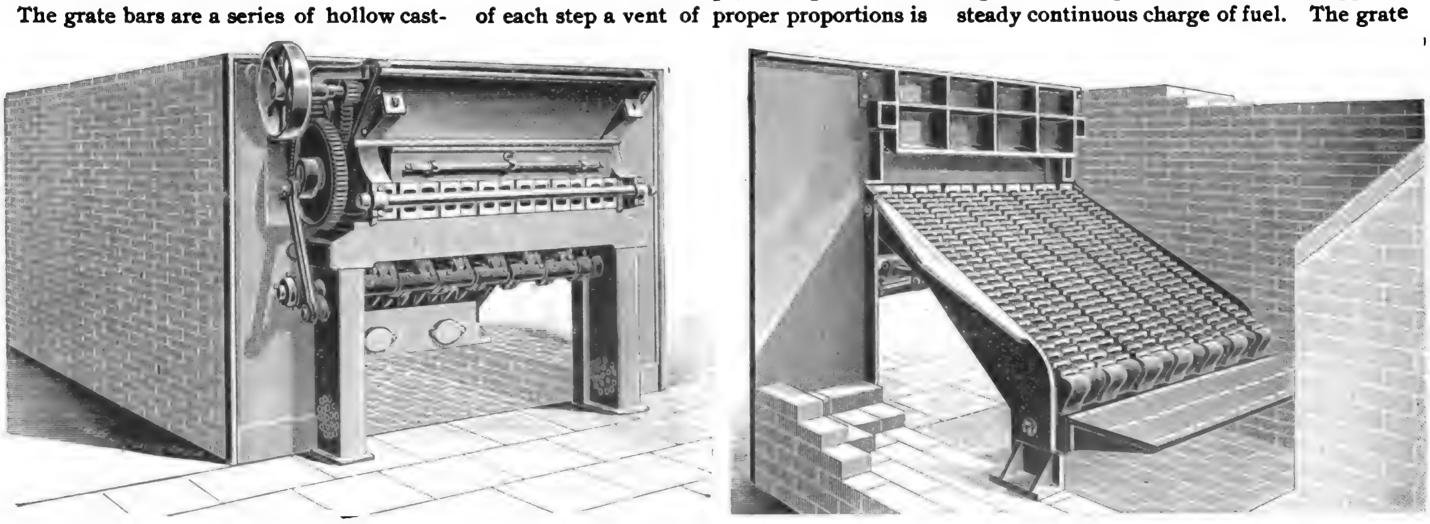
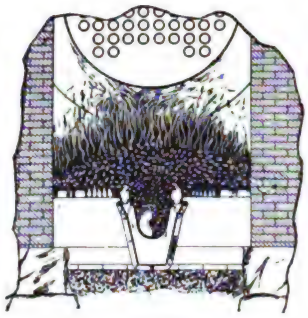


FIG. 3.—WILKINSON STOKER.

a temperature that will cause it to deteriorate. The ashes fall over the rear end of the grate and are removed by an ash conveyor. One of the claims for this type of stoker is that it obviates the nuisance of smoke. In the front of the furnace is a fire arch underneath which the green coal passes for a short portion of its travel; the heat from this arch ignites the gases given off, which then pass over the bed of incandescent coal and are thus thoroughly consumed.



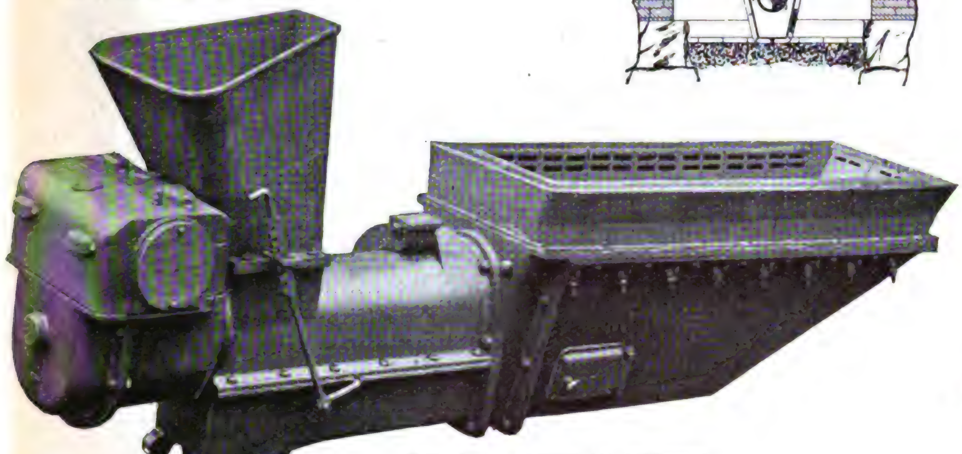


FIG. 10.—AMERICAN STOKER.

The Brightman stoker, shown in Fig. 6, is designed to burn any grade of fuel, from bituminous coal to sawdust and spent tan bark.

The coal-feeding and grate-moving mechanism are secured to and supported by side frames extending from the front line to the bridge wall, and kept at all points below the grates. The bottom of the hopper is formed by a cast-iron feed-table which extends into the furnace as far as the front ends of the grate bars. The space between the lower edge of the furnace front and the feed-table forms a feed-opening or throat the width of the grate.

On the feed-table in front of the throat and inside of the hopper is a pusher to which is given a reciprocating motion by a rocker arm, thereby crowding the fuel through the throat into the furnace, where it is delivered upon the forward ends of the inclined grate bars. The extent of the reciprocating motion and, consequently, the rate of feed, is made simply adjustable.

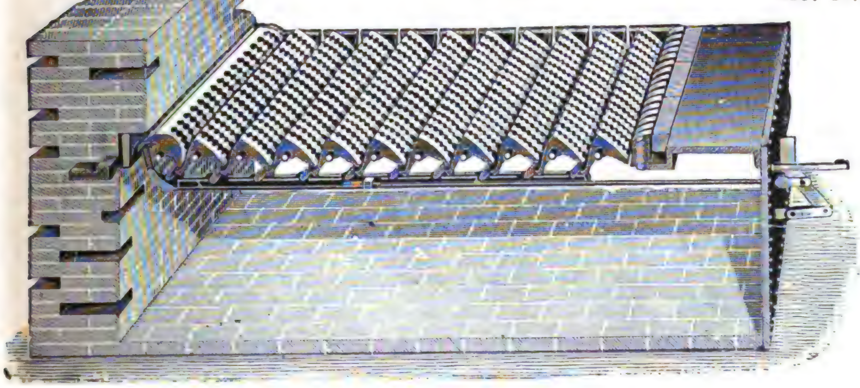


FIG. 13.—M'CLAVE GRATE.

The grate bars are inclined at an angle of about 35 degs. from the horizontal, and are made with overlapping, lateral, projecting lugs, thereby avoiding vertical openings through the grate through which fuel would fall. Every alternate grate bar is stationary, while the movable grate bars rest on bearing bars to which a reciprocating motion is given. The lateral lugs on the vibrating grate bars pass back and forth through those of the stationary bars without coming into contact. The grate vibration keeps the air spaces between the lugs on the bars free of ashes and cinders, and causes the fuel to move down over the surface of the inclined grate at such a rate as to practically insure its complete combustion during its course to the bottom. Such coal as may be unconsumed during the trip passes to a pit grate where it is finally burned. The pit grate is formed of ordinary bars, and has dumping doors through which clinkers and other refuse is occasionally removed, the ashes falling through the pit bars.

The fuel entering the feed opening is delivered at the top of the grate bars, whence the reciprocating motion of the grate bars, aided by gravity, causes it to move regularly along the inclined grate bars toward the rear of the furnace. All fuel on the grate bars moves simultaneously. This movement is positive and uniform, though it maybe varied in volume and rapidity as the demand for steam production varies. This constant and regular movement results in a uniform thickness of incandescent fuel, and an ample supply of air through the grate bars. The motion of the grate bars is longitudinal only and in a horizontal direction, and confined to each alternate grate bar. This motion may be varied from ¼ in. to 2 ins., as may be required by the nature of the fuel, the draught and the evaporative duty required—the adjustment for such variation being easily and quickly made at any time without stopping the machine.

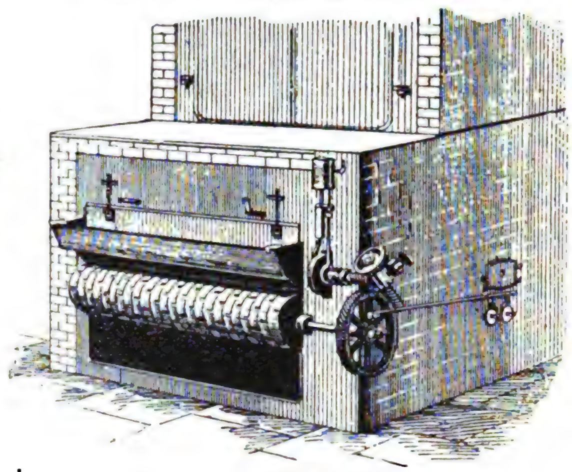


FIG. 11.—CROWE STOKER.

FIG. 12.—M'CLAVE GRATE.

The Murphy mechanical stoker, shown in Fig. 7, differs from the other types described in this article, in that it feeds from the sides instead of from the front of the grate, thereby giving a double coking area.

The upper ends of the inclined grates of the furnace rest against a cast iron plate supported by masonry, part of this plate serving as a coking plate. On the central portion of the plate is an inverted open box—called the stoker box—with a rack at each end. A shaft worked from the exterior has

a pinion gearing to each rack, whereby the stoker box is moved back and forth on the coking plate every 5, 10 or 15 minutes, as may be demanded by the rate of combustion. The stoker box through this motion pushes the coal from the coking plate toward the inclined grate. The triangular piece on top of the stoker box is moved out and in by a lever from the outside, which motion divides the column of coal extending from the magazine above, and assists bringing it down in front of the stoking boxes.

Immediately over the coking plates and on the side of each magazine is an arch plate supporting a fire brick arch. Where the bricks come in contact with the arch plate they are supported by ribs about an inch apart, thus leaving a small air space between each rib. Air admitted at the front of the furnace—the amount being regulated by a register—passes up through a flue in the brick wall, and then over the arch, where it takes up heat from the brick work; it then passes down through the air spaces above referred to, to the fresh fuel on the coking plate. Having been highly heated in its course, the air when it arrives at the coking plates instantly ignites the gases given off by the fuel, thereby preventing the formation of smoke.

By the time the fuel has been advanced to the edge of the grate by the stoker box, the gaseous portions have been consumed and only coke remains, which gets the necessary supply of air for its combustion through the grate. The latter are kept in constant motion by a lever on a shaft rocked by a simple mechanism exterior to the furnace. This motion prevents the formation of clinkers and gradually causes the coke to pass toward the bottom of the furnace. The non-combustible remains are here ground up by the action of projections on a horizontal shaft extending the length of the furnace (shown very clearly in the illustration) and drop into the ash pit. The latter shaft is worked by power continuously. The entire power for making the furnace mechanically self-cleaning, self-shaking of the grates and self-feeding of the coal, is furnished by a 3 in. × 5 in. engine at the side of the battery and, it is claimed, at a cost of less than one-third of one per cent. of the power generated.

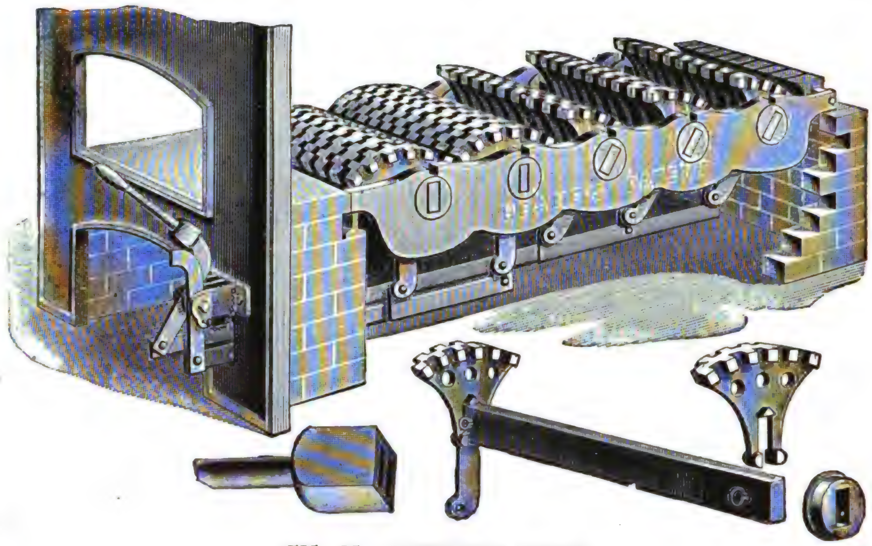


FIG. 15.—ROBERTSON GRATE.

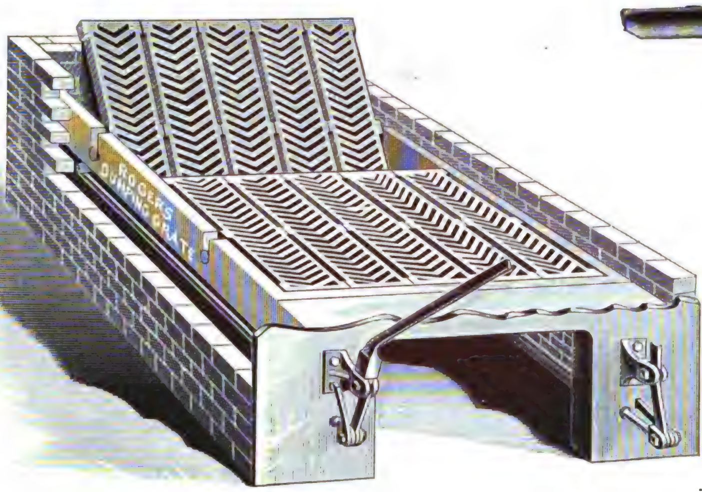


FIG. 14.—SALAMANDER GRATE.

The Babcock & Wilcox stoker, shown in Figs. 8 and 9, is used only for burning bituminous coal, and works with natural draft. It consists of a traveling link grate with a fire on its upper surface, coal being fed at the front by the motion of the grate. The rate of feed is controlled by the amount of opening of a gate in the hopper, and by the rate of motion of the grate surface. Fig. 9 shows the mechanism for giving motion to the grate; the lever shown on the right in both illustrations, controls the feed gate opening. With the exception of the hopper, which is removed, the two cuts show all of the details of the stoker and enable a clear idea to be obtained of its manner of operation.

The American underfeed stoker, illustrated in Fig. 10, employs a forced air draft.

Beneath the coal hopper shown and communicating therewith, is a conveyor chamber, which in turn communicates with a "magazine" in direct line with it. A screw conveyor, or worm, is located in the conveyor chamber, and also extends nearly the entire length of the magazine.

Immediately beneath this chamber is located the wind-box, which has an opening directly beneath the hopper, at which point the piping for the air blast is connected; the other end of the wind-box opens into the air space between the magazine and outer casing of envelope. The upper edge of the magazine and envelope is surmounted by tuyere blocks provided with openings for the discharge of the air blast into the furnace.

Beneath and in front of the hopper is lo-

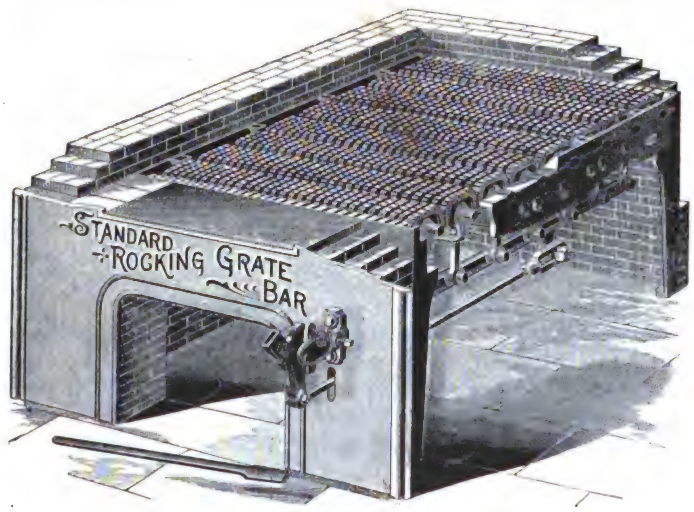


FIG. 16.—STANDARD GRATE.

FIG. 17.—U. S. GRATE.

cated a motor for operating the stoker, consisting of a simple piston steam engine. The cross-head, of this engine, by means of suitable connecting links, operates a pawl mechanism, which in turn actuates the ratchet wheel mounted on the conveyor shaft. The space on each side of the stoker between the tuyere blocks and the side walls of the furnace is occupied by dead-plates or an air-tight grate.

FIG. 18.—THOMPSON GRATE.

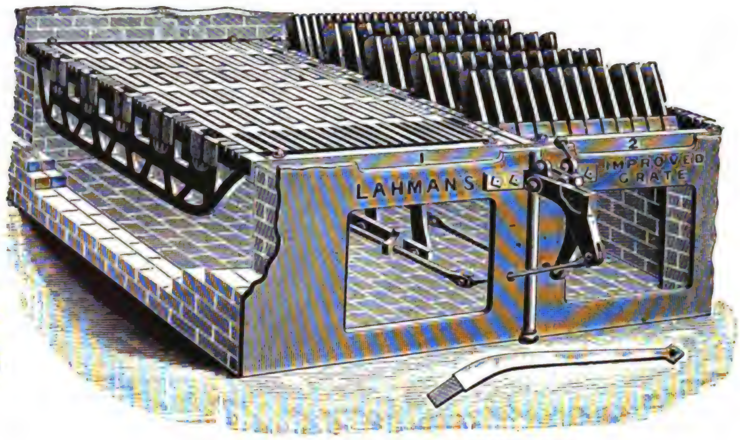


FIG. 19.—LAHMAN-KIRKWOOD GRATE.

The coal is fed into the hopper, and carried thence by the conveyor through the magazine, from which it overflows on both sides and spreads upon the dead-plates the entire width of the furnace. The entire mass of coal above the tuyere blocks and all of that upon the dead-plates is ignited, forming a bed of burning coal from fourteen to eighteen inches in depth.

None of the mechanical parts of the stokers are subjected to heat, there being consequently no deterioration from this cause. The tuyere blocks, through which the air is

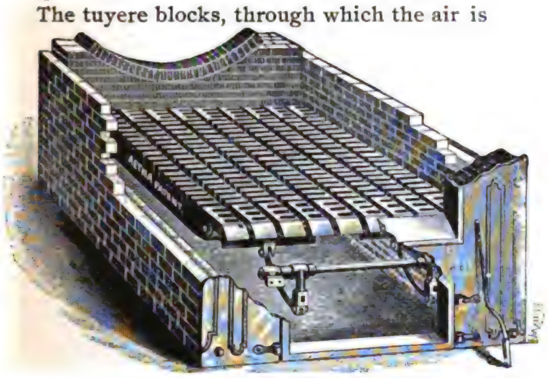


FIG. 20.—ÆTNA GRATE.

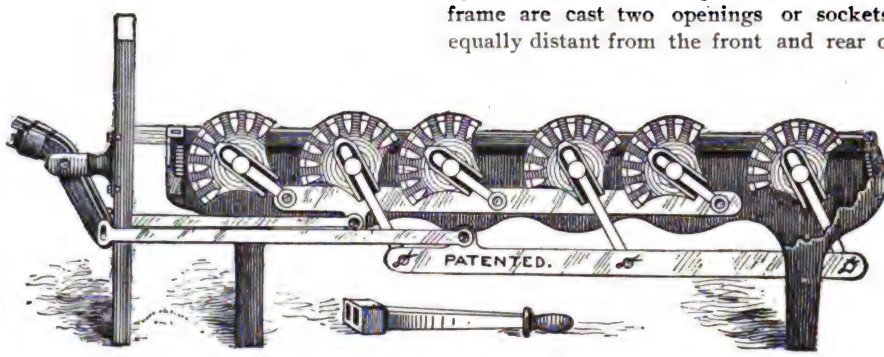


FIG. 22.—MACKNET GRATE.

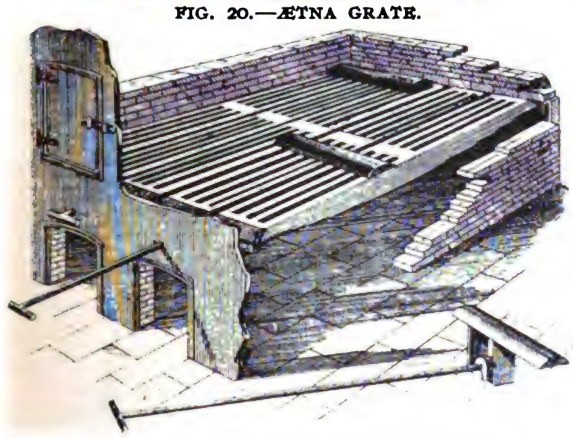


FIG. 21.—WORTHINGTON GRATE.

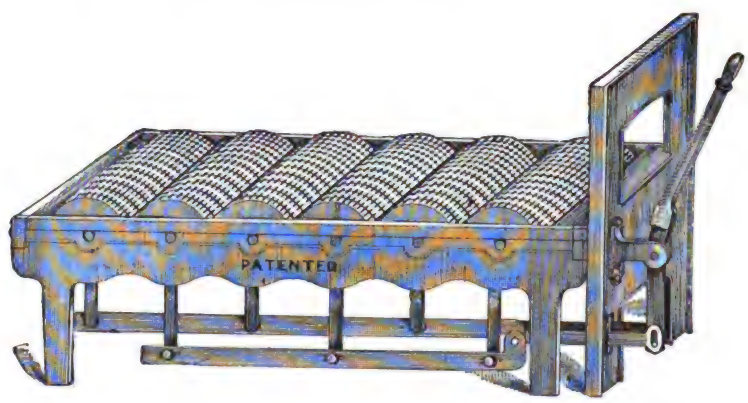


FIG. 23.—MACKNET GRATE.

distributed, are kept cool by the currents of air passing through them. These blocks are ordinary castings and easily and cheaply replaced.

The Crowe mechanical stoker, shown in Fig. 11, is constructed on the link grate system. Coal enters upon the grate from the hopper and immediately ignites. Hot air is admitted and distributed over the coal through an arch plate supporting a fire brick arch, and in such quantities as is necessary to coke the coal, thereby facilitating combustion and preventing smoke. The grate is constructed by linking together small grate bars, thus making an endless chain which is moved by a power shaft and sprocket wheel.

The McClave shaking and dumping grate is shown in Figs. 12 and 13, the latter illustrating the shaking, and the former the cut-off movement. In their normal position the bars form a surface which, owing to shape of the upper surface of the bars, is slightly corrugated longitudinally.

The grate operates on the "pocket" principle, the bars forming, when thrown wide open as in Fig. 12, a series of pockets to receive the clinkers and ashes, which cannot pass through into the ash pit until the bars have been thrown back into their normal position. A certain quantity of clinkers and ashes is thus "cut-out" at each extreme movement, thus uniformly removing the under side of the fire. During the shaking movement, illustrated in Fig. 13, the front ends of the fingers of each bar remain equidistant from the curved back of the bar in front of it, there thus being at no time an increase in the size of the openings. This movement is produced by working the lever shown to and fro between the stop and boiler front, while for the cut-off movement the lever is pulled forward to its full extent and pushed back again to the stop. The shaking movement is well adapted to the breaking up of soft coal fire when it cakes, since nothing passes through into the ash-pit but fine ash. A fire of small anthracite coal is built up until the bed has attained a depth of at least 10 ins. when it is cut down.

The Salamander dumping grate is shown in Fig. 14. A cast iron frame is made to encircle the furnace, and with a leg at each corner of sufficient length to rest upon the floor of the ash pit. Into each side frame are cast two openings or sockets, equally distant from the front and rear of furnace. In these openings or sockets are swung the rockers, which run diagonally across the furnace. Each rocker is cast with an arm, which is connected, by a wrought iron rod, to the dumping attachment at the front of the furnace.

The sectional grates are made with a groove cast into the deep longitudinal ribs,

and of such dimensions as to fit easily over the rocker upon which they rest. A light bearing bar is placed between the two side frames and in the center of the furnace.

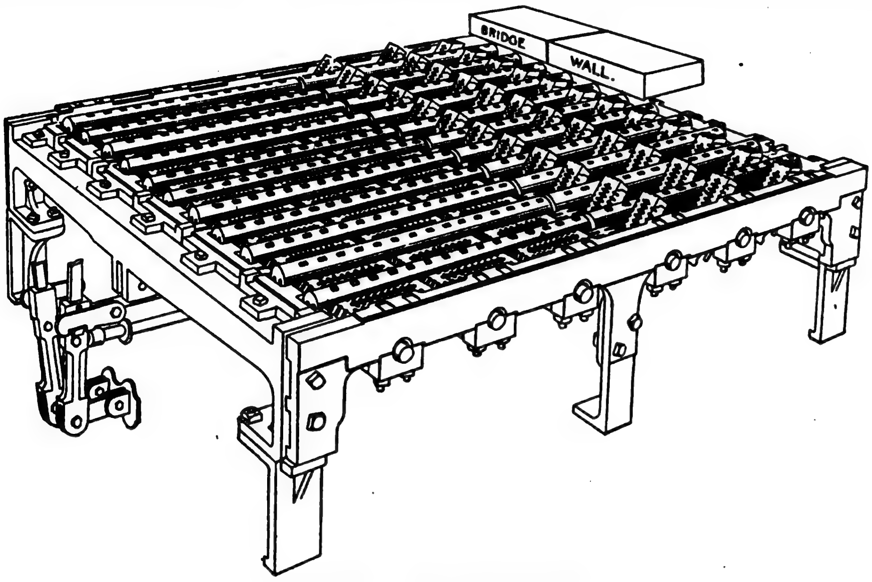


FIG. 24.—REAGAN GRATE.

This bearing bar and the stop bar connected with the dumping attachment at the front of the furnace prevents any danger of the bars being displaced unintentionally.

In Fig. 15 is shown the Robertson shaking and dumping grate with details of the bars. As will be seen, each bar is made up of a number of leaves or sectors, thus facilitating and reducing the cost of repairs. The front and back sections can be dumped together or separately with one lever. The method of operation of the grate is so plainly illustrated by the cut as to require no further explanation.

The "Standard" rocking grate bar, shown in Fig. 16, has two motions, one for shaking and another for dumping, the latter being accomplished by removing a wedge-shaped piece in the shaking arrangement—shown in the illustration attached to a chain.

The different bars composing a set are placed in a frame made in sections and standing on four legs; consequently no alteration is required in a furnace to be fitted, four straight walls being all that is necessary. Each bar is composed of a main body piece having trunnions on each end, the surface that is in contact with the body of fuel being made up of removable leaves. These leaves are placed on the main bar by entering them vertically in a slot, and then passing them transversely into position—in other words, stringing them upon the bar. A bead at the upper part of the body bar keeps the leaves from being detached vertically, and a key leaf is placed on the main bar at the point where the bead is discontinued; this latter leaf has longer shanks thun the others, and also has holes in the lower part of the shanks through which a split pin is inserted. So long as the key leaf remains in position, the other leaves cannot get off the main bar, as the part of the bar occupied by it is the only place at which the leaves can be removed.

The main part of the body bar is protected from the direct action of the heat by the leaves coming closely together for some distance down the bar. There is a slight amount of "play" between the leaves and the main bar, and owing to the air space thus provided, the main bar does not receive heat enough to warp it; moreover, as each leaf is loose, any tendency to warp is confined to the leaves themselves, and cannot be transmitted to the main bar. When desirable, either from the change of the size of coal or for any other reason, that a different size of air space be used, another set of leaves may be substituted, the main framing and other parts of the bars remaining the same.

The United States rocking grate is illustrated in Fig. 17, the engraving showing the grate in position for use, a part of the frame being cut away to expose the connections beneath. The bars carrying the clips which form the surface of the grate, are so pivoted that every alternate one is higher than its neighbor. The result is that when the lever is moved to clean the grates, every alternate bar is moved through the arc of a larger circle. This gives a large opening between the alternate rows, and at the same time brings two bars close together to support the body of the fire, the incombustible matter falling through the openings into the ashpit beneath. The return motion of the lever brings the larger opening between the two rows that were close together at the first movement, thus opening up every part of the grate surface in two movements of the lever.

During these motions of the grate its surface remains perfectly level, there being no projections to turn upward and disturb the fire when shaken. All ashes and clinkers are removed by the operation, leaving the fire clean, bright and unbroken. The full throw of the lever is only used for removing clinkers. For ordinary cleaning a slight to and-fro movement of the handle is sufficient.

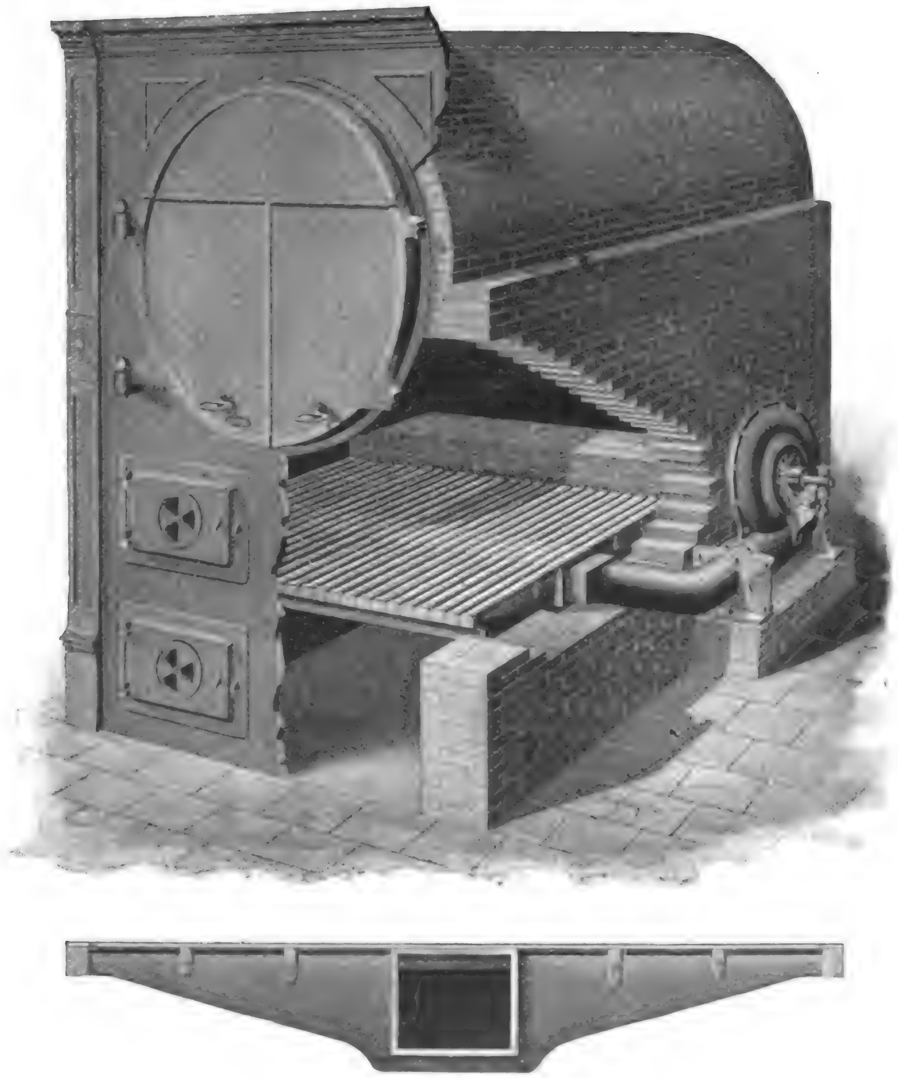


FIG. 25—GADEY GRATE,

These grates are so balanced that but a short lever and a little strength are required to operate them. They do not depend upon the brickwork for support, but have an independent frame. The grate supports are so far below the fire that they do not burn out or warp. The only parts coming in contact with the fire are the small saddles or clips—shown separately in the engraving—which can be replaced at the cost of a few cents each. As these have no points or ends exposed to the fire, they will last for years without replacing, while the other parts of the grate are subject to no deterioration from heat.

The Thompson sectional dumping grate, shown in Fig. 18, is adapted especially for burning cheap grades of fuel, such as pea and buckwheat, screenings, etc. One-half of the furnace can be dumped at a time thus enabling an ordinary furnace to be cleaned in a few minutes. The bars of the grate are made in several sections, thus allowing for expansion and obviating warping.

The Lahman-Kirkwood shaking and dumping grate bar is shown in Fig. 19. The grate consists of a framework connected by wrought iron crossbars at intervals of about 16 ins.; upon these crossbars are hung the "finger" pieces constituting the coal carrying surface. These fingers have hollowed air-chambers on the under side next the crossbar, thus allowing free circulation of air and preventing warping of either the fingers or the crossbars. The fingers weigh but a few pounds each, are interchangeable, and can be replaced if necessary without difficulty at a trifling cost.

The surface of the grate is level and held so by a simple lock. The principle of the bar is that the fingers act as knives which press up into the burning fuel and separate it, thus preventing the forming of clinkers; the same motion thoroughly cleans the fire without breaking up (unless desired) the top of the fire. The air spaces, being of serpentine shape, permit of large openings without the waste possible if a common bar were used. The fire can readily be pushed from one-half of the grate to the other (a complete grate being made for each fire door), and the ashes and cinders dumped instantaneously into the ashpit, thus maintaining an even pressure of steam with consequent saving of steam.

The Aetna shaking grate is shown in Fig. 20. Upon ordinary bearing bars are placed two or four stationary bars (according to the width of the furnace), between which near the ends are suspended the rockers—shown separate in the cut. Upon these rockers are placed the moving bars—also shown separate—a level surface being presented when the bars are at rest. When the lever connected to the rockers is worked, both a horizontal and vertical motion is imparted to the bed of fuel, whereby the under surface is thoroughly cleaned and opened.

The Worthington grate and slicing device (Fig. 21) employs the ordinary form of straight bar, over the surface of which a slicing tool is passed; the illustration very clearly shows the construction and manner of operation of the latter.

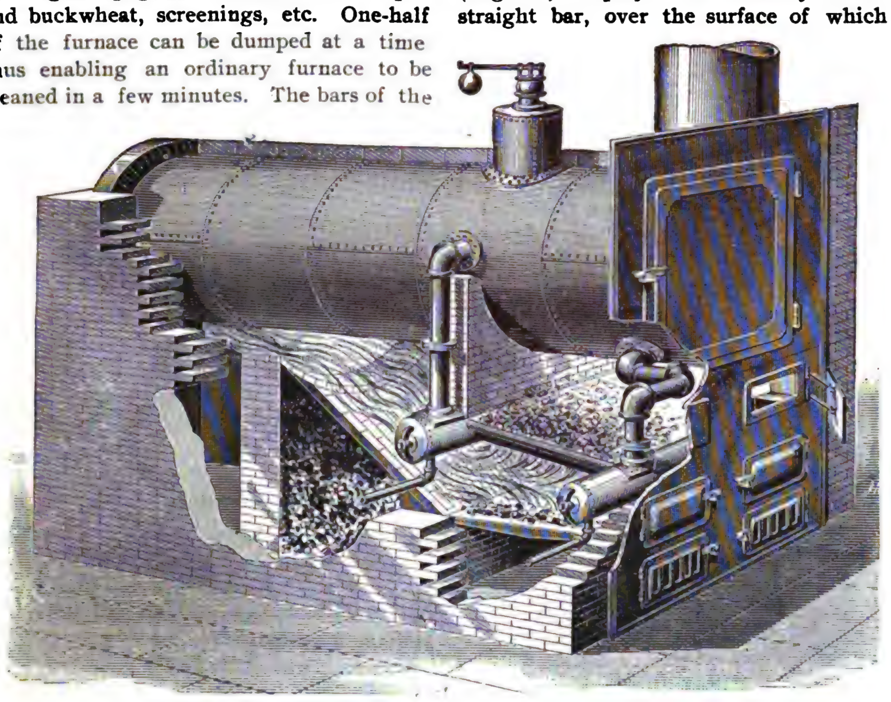


FIG. 26.—HAWLEY DOWN-DRAFT FURNACE.

The Macknet rocking grate is illustrated in Figs. 22 and 23, the latter showing the grate when the bars are in motion. The bars, by means of long and short levers, are given a movement which enables the grate to open from three to four inches, this movement forcing the clinkers and unconsumed fuel to fall into openings, where they are cut off without breaking or disturbing the fire bed, thus permitting small and cheap coal to be burnt without the loss of unconsumed fuel. The grate surface is composed of 2×6 in. sections dropped on a bar to receive them, the fire not coming in contact with this bar and therefore not tending to warp it. The sections, if necessary, can be withdrawn and repaired without drawing the fire. The bars are so arranged that they can be cleaned in part or in whole as desired without opening the furnace doors.

Fig. 24 shows a Reagan dead-bar chopping grate, the construction of which is made plain by the illustration. The open gaps of greater or less extent formed by the ordinary grate when shaking or dumping, and which allow coal to fall through, are obviated in this grate by dead bars which bridge up the fire. Choppers come up between these bars (which are circular in section) and cut out the bottom of the fire, thereby doing away with the formation and accumulation of clinkers and allowing the fires to be run for weeks without hauling, or other means of cleaning, the use of a hoe or slice bar being thus rendered unnecessary. The shaking device is simple but positive, and when locked in a certain position levels the surface of the grate, no choppers remaining up in the fire to burn out. The locking device also allows of a shaking or dumping motion, both for the front and back and separately, as may be desired. The dead bars are merely dropped into slots and are interchangeable; the choppers are simply keyed to a square bar. Both choppers and dead bars are hollow, thus allowing of circulation of air; they are light in weight and can be replaced at very small expense. The manufacturers claim that this grate has more air space than any other bar known.

Though outside the scope of this article, descriptions of two special forms of stationary grates—the Gadey and the Hawley—are added, owing to the several interesting features which they possess.

The Gadey air grate is shown in Fig. 25 as applied in a boiler, together with a view of a separate bar. The grate is composed of hollow cast iron grate bars 2¾ ins. wide, so constructed that when they are placed together to form a grate, a uniform supply of air can be injected in them from a pressure blower and delivered from the interior of the bars through slots to the furnace. The jets of air thus entering also induce a draft from the ash pit through the interstices of the bars. There are two vents to each bar, which are located at the edges and extend longitudinally almost the entire length of the bar, the distance between vents being 2½ ins.

A side view of a bar is given in the lower part of Fig. 24. The central opening forms a supply chamber extending through the furnace, the butting portion of the bars having planed surfaces to make an air-tight joint. The air is forced through the vents or slots into the furnace at an angle of 45 degs., the two currents from adjacent bars impinging over the space between them and inducing a draft from the ash pit. The draft of air can be adjusted to the kind of fuel used or to the desired rate of combustion.

The Hawley down-draft furnace (Fig. 26) has two separate grates, one above the other. The upper one is formed of a series of tubes opening at their ends into steel drums or headers, connected with the boiler, through which tubes the boiler water continually and rapidly circulates. It is this upper grate alone which is fired, and the down draft from the upper fire doors carries the gaseous matter from the green coal consumed on the upper water tube grates through this mass of fuel. Whatever gases escape unconsumed are then burnt by the flame from the lower grate. The lower grate, formed of common bars, is entirely fed by the half consumed fuel falling from the upper grate; as the flame from this source ascends, it meets the downward burning fire from the upper grate, the joint draft current passing through the flues in the usual way. The water tubes, besides acting as a grate, give with their connections, some additional heating surface.

PRACTICAL METHOD OF DIFFERENTIAL COMPOUNDING A SHUNT MOTOR FOR CONSTANT SPEED AT ALL LOADS.

BY REESE HUTCHISON.

The following will be found a practical and reliable way to compound differentially a shunt motor for absolute constant speed under varying loads:

Wind over the shunt fields of the motor an experimental coil of large wire, and in a direction opposite to the winding of the shunt fields. Note the number of turns of experimental coil—at least one layer being wound on the fields.

Run the motor as an ordinary shunt machine, at no load, and take speed. Then throw on full load, and note the number of amperes taken by the motor.

Stop the motor and remove the ammeter, placing it in series with the experimental coil at *A'*.

Connect the end, *R*, of the experimental coil to the positive main at *S*. Then, the current passing through the coil, ammeter, *A'*, and temporary starting box, *V*, to the negative main at *P*, will, being wound contrary to the shunt winding, tend to oppose the magnetizing effect of the shunt coils, thereby weakening the fields.

Having connected as shown in Fig. 1, leave the experimental coil circuit *open* and start the motor up under full load. The speed will be below the speed attained at no load in the first part of the experiment. Now close the experimental circuit, having all of the resistance of *V* cut in. Gradually cut out *V* by moving the lever slowly until the motor comes up to initial speed. Note

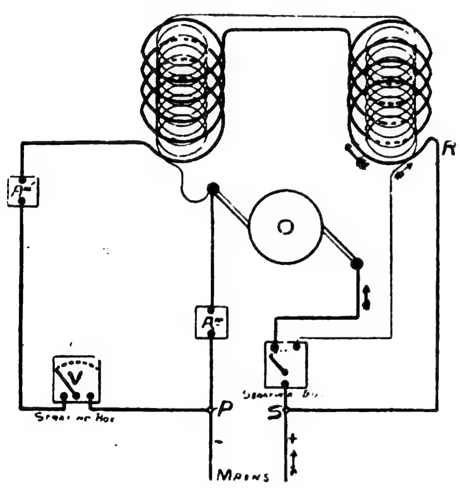


FIG. 1.—CONNECTIONS OF TRIAL COIL.

the amount of current taken by the experimental coil, and, by dividing the product by the amount of current taken by the motor when it was run as a shunt machine at full load, we have the total number of convolutions, which, divided by two (or the number of field coils) gives the number of convolutions to be wound upon each field coil.

The theory of this self-regulation is that when the magnetic field of a shunt motor is weakened, the speed increases. Now, when the differential motor is running at no load, very little current is taken; hence, the magnetizing effect of the shunt winding is at its maximum. As the load is thrown on, more current passes through the series winding, and this tends to magnetize the fields oppositely to the shunt winding, thereby weakening the magnetic field and allowing the armature to rotate faster. The heavier the load, the more the field is weakened, and the speed thus kept constant.

The wire on the series field must, of course, be large enough to carry the current taken by the shunt machine when it was run at full load.

The connections of the finished machine are shown in Fig. 2. Notice that the cur-

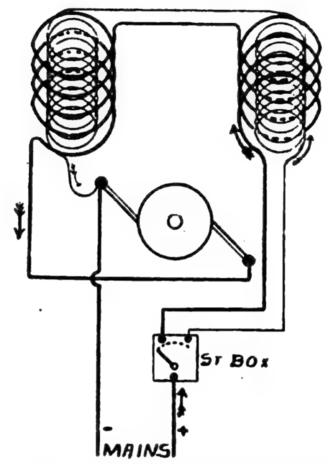


FIG. 2.—FINAL CONNECTIONS.

rent passes through the series winding and then to the armature in this case. Therefore, the same starting box is used, but the connection referred to is changed. In starting up, the current is thrown into the shunt fields before the series fields and armature are cut into circuit. If this is not done, the machine will run backward, and against the brushes.

A convenient rule to follow in order that the amount of wire necessary to wind on may be ascertained, is given below. By finding the diameter of the bare wire from a wire table, then adding the values given below, the diameter of the insulated wire may be found. In order that the number of pounds of the wire necessary may be found, multiply the diameter of the insulated wire by the number of convolutions on one field, and divide by the available winding space between magnet heads. This gives the number of layers on one field. Now get the diameter of *shunt* finished field, add the diameter of finished entire field after the series coil is wound on, and divide by 2 and multiply by 3.1416. This gives the mean length of one convolution, which, multiplied by the number of convolutions in one layer, gives the mean length in one layer, which, multiplied by the number of layers on one field and multiplied by the number of fields gives the entire length of wire to be purchased. Add five or ten per cent. to allow for connections, etc. Consult a wire table for the weight of wire.

To find outside diameter of magnet wire, cotton covered, over insulation, add, for single cotton covered, to bare diameter,

.007 ins. from No. 0 to No. 11
.005 ins. " No. 12 to No. 24
.0045 ins. " No. 25 to No. 31

Double these values for double cotton covered.

THE EQUALIZER.

BY "PRACTICAL".

Every one directly interested in the running of dynamo machines is familiar with the name and office of the equalizer, but not so many understand its action well enough to anticipate its troubles and prevent them. Providing means for running compound-wound dynamos in multiple without fear of overloads and reversals, it represents one of the unwritten laws of power station practice.

There are four conditions under which compound-wound dynamos can be run in multiple: 1. With the armatures rigidly coupled. 2. With a slack belt on both machines. 3. With a high line resistance between the two machines. 4. By means of an equalizer.

Let us suppose we have two 500-volt 500-ampere compound-wound generators as nearly similar in all respects as they can be made, and connected as in Fig. 1, where *S* and *s*, *S'* and *s'* are the series and shunt coils respectively of dynamos *A* and *B*, *R* and *R'*, *K* and *K'* being respectively the field rheostats and line switches. Suppose *A* and *B* to be direct connected to the same engine and to be running at 500 volts on open circuit, that is, with shunt fields excited, but with *K* and *K'* open. Upon closing *K* and *K'*, *A* and *B* will deliver current to the line and in doing so will excite *S* and *S'*, and if the windings are exactly similar and the iron the same in quality, will take the same load. Practically these conditions are seldom realized, because it is impossible to get two machines exactly alike in all respects; their loads will therefore differ slightly, and more so if one machine is hot and the other cold, for the hot machine has greater internal resistance and its magnetic circuit has less permeability, and will therefore induce less magnetism for a given nnmber of ampere-turns.

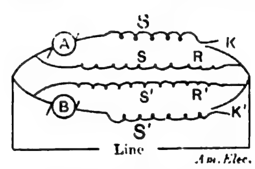


FIG. 1.—TWO DYNAMOS IN PARALLEL.

Assuming, however, that the machines are doing service and that the load is fairly well divided between them, the ratio will remain the same, however the line current may vary, because the speed is the only variable factor, and since the armatures are rigidly connected, any reduction in the speed of one, thereby reducing its E. M. F. and hence the amount of load contributed, is attended by a similar reduction in that of the other, thus preserving their load relation.

Next suppose the machine to be simply belted to the countershaft with the usual tension on the belts. In this case, if one machine's speed drops a little, its voltage will do likewise and will contribute less to the line current. On the other hand, the remaining machine will contribute more current to the line, and this current passing through its series coils will thereby strengthen its field and raise its E. M. F. and enable it to send more current, which will further increase its field; this reactive effect

between the series field current and the E. M. F. is aided by a similar but opposite effect on the lower speed machine, which shirks its load until the overloaded machine loses its belt, unless the lower speed machine's voltage becomes so low that the other sends a back current through it and "motors" it; in this case, if its series coils are strong enough to overpower the shunt coils, the direction of rotation is reversed and the belt thrown. The switch should be immediately opened to avoid danger of mechanical injuries incidental to high speeds.

Let us now suppose the belts of both machines to be slack. Under this condition, as soon as decrease of speed on one machine (say A) throws more load on the other (B), its belt slips, reducing the armature speed and hence voltage, so that the machine cannot become overloaded. This see-saw action between the belts equalizes the loads in a measure, but is practically prohibitive on account of its inefficiency, because both machines cannot be run at full load at the same time.

Condition 3 is realized when power stations at a distance are run in multiple with each other, and gives the more satisfaction the more dynamos there are in each station, because a given variation in load is then a lower percentage of the whole load, is distributed among several machines and is hence not so marked in its effect on each machine. In Fig. 2, suppose, P and P' to be power stations situated one mile from

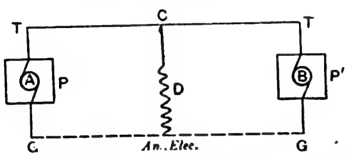


FIG. 2.—TWO POWER STATIONS IN PARALLEL.

each other and containing one compound dynamo each, whose circuit is through the trolley wire, T, T, and the ground, G G. Suppose D to be a variable load situated midway between P, and P'. If the resistance of the whole circuit, $T C T B G G A$, is two ohms, the resistance of half of it will be one ohm. Assuming the line to be well insulated, the maximum current which either dynamo could be called upon to deliver would be that following a short circuit in the device at D. Under this condition, the current in a dynamo could not exceed 500 amperes $= \left(\frac{500}{1}\right)$, where 500 is the dynamo voltage and one ohm is the resistance of half the circuit. If A and B are of 500 amperes capacity each, this would not throw the belts, and the greater the station's capacity the less the effect. We see that the line resistance acts as a cushion between the two machines, and the effects of minor variations due to speed fluctuations are much modified.

An equalizer, as its name implies, equalizes, and is used to equalize the current between compound-wound dynamos running in multiple. We will first consider the case where the two machines are alike as far as they can be made so, and Fig. 3 gives the connections. For simplicity we omit the shunt field in the diagram. K'', is a switch in the equalizer, $P P'$, which is a stout copper strip joining those brushes of the two machines which are attached to the respective series fields. The machine's polarities are such that these brushes are at the same potential on open circuit, so that the closing of K'' would then have no effect. Should the equalizer be by mistake placed across brushes of opposite sign, the result would be a short circuit upon closing K'', even with K and K' open.

Suppose that A is running with load and that it is wished to put B in service. B is brought up to speed and its open-circuit

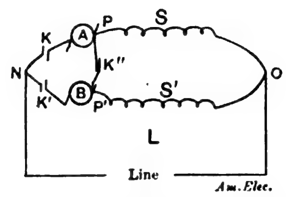


FIG. 3.—EQUALIZER CONNECTION.

E. M. F. adjusted to 500 volts with the field rheostat. K'' is then closed, which puts $P P'$, in series with S', and the two in series are in multiple with S, so that A's current arriving at P has a double path to point O—one through S, and the other through $P P' S'$. This weakens S, and reduces A's voltage, but strengthens S', and increases B's open-circuit voltage, so that when K' is closed, B's armature contributes to the line current, and in doing so raises S''s strength and also the potential of point P'. The potential difference between the two ends of the equalizer is thereby diminished, and consequently the amount of current supplied by it to S', till, when A and B carry the same current, P and P' are at the same potential and the equalizer carries no current. If now the speed on either machine (say A) falls, A's voltage falls and so does the potential of point P. Consequently current from B flows through S and strengthens it. The lower A's speed, the lower is P's potential, and the greater the current through the equalizer. If B's speed drops, equalization takes place towards S'. In either case the equalization is very much helped by the fact that when the equalizer gives to S it robs S', and *vice versa*. The equalizing current is thus sometimes in one direction and sometimes in the other, and sometimes it is zero.

From the fact that the equalizer is always in series with the series field that needs strengthening, it follows that its resistance must be very low in order that its own resistance in series with that of the field to be strengthened may not too much exceed the resistance of the series field to be robbed and thereby impede regulation. If S and S' are of the same resistance and that of $P P'$ is zero, regulation will be perfect; but the nearest that perfect regulation can be approached is to have $P P'$'s resistance as low as possible. The writer has in two cases improved regulation by increasing the equalizer's size and perfecting its connections.

This brings us to the case of two compound-wound dynamos of different sizes running with an equalizer. If machines are of different sizes and makes, their series field resistances are apt to be in the wrong ratio to secure good regulation. Compound-wound dynamos will only regulate with an equalizer when the series field resistances are inversely proportional to the currents which they must carry at full load. In other words, current of $A' \times$ resistance of S must $=$ current of $B' \times$ resistance of S'. If A's current capacity is three times B's, B's series field resistance must be three times A's. Let A's capacity be 500 amperes and let S measure .02 ohm; let B's capacity be 250 amperes, what must S' be? 500 amperes $\times$ .02 $=$ 250 amperes $\times$ S', whence $S' =$ .04 ohm. Now if S' happened to be .025 ohms, it would be necessary to put in series with it an extra resistance equal to .04 — .025 $=$ .015 ohm, the amount which S' differs from the required value. This is done as follows: suppose S' is wound with No. 3 wire; No. 3 B. & S. wire measures .000196 ohm per foot, and to get a resistance of .015 ohm would require (.015 $\div$ .000196) ft. $=$ 76 ft.; this wire is rolled into a coil and inserted in S' between two of its spools. On the other hand, suppose A's current to be 500 and S to be .01 ohm, while B's current is 250 and S' is .04 ohm. In this case the extra resistance would go in S and would be .01 ohm, because 500 $\times$ S must equal 250 $\times$ .04 ohm, whence S should be .02 ohm. But we have supposed S to be .01 ohm. Therefore it must have in series with it a resistance equal to (.02 — .01) $=$ .01 ohm.

The disadvantages attending the running of compound machines in multiple when the series field resistances are not in proper relation, can be seen by supposing that A's capacity is twice B's, but that S and S' are of equal resistance. Suppose A to be running under full load; upon closing K'' the current divides equally between S and S'; S' would then have full current though B's armature be inactive; upon closing K', B would further excite S' and tend to take more than its share of the load. As a matter of fact to be deplored, this overloading tendency is generally overcome by changing the field rheostat, thus losing the machine's compounding feature. The above condition must be distinguished from that of running with equalizer machines of different degrees of overcompounding; in this case it may be necessary to adjust or even remove a series field shunt.

The equalizer practically prevents a dynamo's being "motored" as long as the line circuit is closed, because the machines then have a common path through which to send their currents, and will do so even though their open-circuit voltages may be different; but upon open-line circuit, as at L, the machines are left to react upon each other in the local circuit, $N A S O S' B N$, and any great discrepancy in their open-circuit voltages generally announces itself by a flash at the brushes, so often seen on street railway generators without apparent reason.

The Western Society of Engineers.

The greater portion of the December issue of the *Journal* of the Western Society of Engineers is taken up by an article on "Electric Traction," by Edw. Barrington, and another on "The Equipment of Manufacturing Establishments with Electric Motors," and "Electric Power Distribution," by Prof. D. C. Jackson. The discussion on the former paper is very extended, and includes a number of tables of estimates of cost.

LUBRICATING OILS.

BY C. A. COLLETT, V. P., N. A. S. E.

Lubricating oils may be divided into five classes, as follows: 1. For very fine and light machinery. 2. For machine tools, wood-working machinery and dynamos. 3. For roughly constructed and slow speed machinery. 4. For steam engines, and all kinds of machinery which have bearings affected by heat from outside sources. 5. For steam engine cylinders. The first three oils mentioned above may be purely animal or purely mineral oils, or a mixture of both. The last two are almost invariably composed of mineral oils.

Mineral oils do not decompose, but volatilize more or less rapidly according to their composition. Benzine, naphtha, and gasoline are highly volatile and consequently unfit for purposes of lubrication. All animal oils are subject to decomposition under a high temperature, and consequently are unfit for lubricating purpose, when placed in contact with very high pressure steam or with dry heat at a high temperature. Lard oil, while it is a very desirable lubricant for cold surfaces, decomposes at 380 degs. F; and besides this, it is objectionable as a cylinder oil when the feed-water is in contact with the exhaust steam, because it causes foaming in the boiler. The best grades of mineral cylinder oils do not volatilize under 675 degs. F., which is equivalent to a steam boiler pressure of more than 1000 lbs. per square inch.

Mineral oils, unless slowly and carefully filtered, will be found to contain gritty matter, and in view of this fact all mineral oils, and particularly all those to be applied to sensitive bearings, should be tested for gritty matter. The cheaper grades of lubricating oils and not a few of the more expensive grades, are filtered under pressure, which permits gritty matter to pass undetected. In order to insure lubricating oils to be free from any grit whatever, they should be gravity-filtered in a warm room, through woolen blankets, or, preferably, felt.

Sperm oil is decidedly the best lubricant for machinery when it is not placed in contact with steam, or with any heat.

Next in order of preference comes lard oil. Several instances have come under the writer's notice, where lard oil effectually stopped the groaning of a steam engine piston and greatly reduced the power required to actuate the slide valve, after the best grades of mineral oil had been tried and abandoned as inadequate to the purpose. Where lard oil can be used without contaminating the boiler feed-water, it is to be preferred to mineral oil as a cylinder lubricant. We make this assertion in the face of the fact that in the French navies none but mineral oils, pure and simple, are permitted to be used for all purposes of lubrication.

The cheaper grades of mineral oil are filtered under pressure when filtered at all, and are run through bone black, charcoal, or flannel blankets quickly; consequently, they contain much gritty matter, and for sensitive bearings they should be rejected on this account, if on no other. Pouring a little mineral oil on a card or a piece of glass, and rubbing it with the finger, is not a good test of its lubricating quality, as many suppose, for it is evident that a body may be given to an oil by mixing it with gelatine, or even common cheap grease.

A prime lubricating oil, other than a cylinder oil, should have three properties, namely viscosity, unguency and fluidity. By taking the best grade of cylinder stock and thinning it while warm with 24 gravity paraffine oil, sufficiently to cause it to pass freely through a sight-feed lubricator, and then carefully filtering it, we can produce a perfect cylinder oil. If lard oil or tallow oil is used as a lubricant, we would recommend that it be first de-acidized.

To engineers and all others buying lubricating oils, we would say: As a first precaution to secure good lubricants, deal only with reputable concerns, who will guarantee to furnish a uniform quality of oil every time, paying them a fair price which agrees with the standard market quotations. When a drummer comes along and agrees to furnish you a better oil at fifteen per cent. less price than you are then paying, it is well to be cautious. In order to secure your trade, he may give you straight goods on your first order, but on subsequent orders it would be well to examine closely into the quality of the goods.

A good test for oil is to place single drops in line upon a piece of plate glass, about 8 ins. wide and 24 ins. to 30 ins. long, one end being raised about 6 ins. to 8 ins. to form an inclined plane. The drops of oil start from the top of this inclined plane upon a race with each other. The first day sperm oil will be found in the rear, but after a while it will catch up and overtake the rest and will even be found in motion after the other oils have dried up. An oil having a light body runs quickly and dries quickly, but an oil that has both body and a free flow will readily be detected by this test. An oil may have a good body and yet have a tendency to gum badly, which quality will also be easily detected upon the glass. The oils should be covered from the dust while these tests are being made.

A good test for the presence of acids is to put small quantities of oil in copper dishes, which are easily made by depressing bits of sheet copper with a round face hammer. If acid is present it will attack the copper and produce verdigris.

Very little has yet been published concerning the action of oils in common use on metals with which they are brought in contact when employed for the lubrication of machinery; and as the subject is one of importance, especially to manufacturers of compound lubricating oils and to those who use such oils, we give the results of experiments carefully made and extending over a period of twelve months. It was found that iron is least affected by seal oil, and most by tallow oil when it is not de-acidized. Brass is not affected by rape oil, least by seal oil, and most by olive oil. Copper is not affected by mineral lubricating oil, least by sperm oil, and most by tallow oil. Mineral lubricating oil has no action on zinc and copper, acts least on brass and most on lead. Tallow oil acts least on tin and most on copper. Lard oil acts least on zinc and most on copper. Sperm oil acts least on brass and most on zinc. Seal oil acts least on brass and most on copper.

From the foregoing results it will be seen that mineral lubricating oil has, on the whole, the least action on the metals experimented with, and sperm oil the most. For lubricating the journals of heavy machinery, either rape or sperm oil is the best oil to use in admixture with mineral oil, as they have the least effect on brass and iron, which two metals generally constitute the bearing surfaces of an engine. Tallow oil, unless it is de-acidized, should be used as little as possible, as it has considerable action on iron.

While it is true that on steamboats navigating our Western waters, many engines are run without the use of any cylinder oil whatever, dependence being placed on the water of condensation for the prevention of friction and cutting of cylinder and piston, yet water cannot be recommended as a desirable or safe lubricant for such purpose. It is true that cold water applied constantly to a bearing will prevent its heating, but this is not due to any lubricating properties in the water, but to the fact that the water rapidly and wholly absorbs the heat given off by the friction of the bearing surfaces. In a slow speed vertical engine, with the piston perfectly in line with the axis of the cylinder, the water of condensation will take the place of oil, and give good results so far as the wearing of the surfaces is concerned, while it costs nothing as a lubricant. But for general and indiscriminate dependence as a cylinder lubricant, the water of condensation is not to be recommended. It will also be found that, wherever the water of condensation has been made use of as a cylinder lubricant, the piston, and piston stuffing-box were packed with cotton rope and hemp. Under these circumstances, and under proper conditions, such as slow speed, accurate alignment of moving parts, etc., it may be possible to properly lubricate a cylinder with water.

NOTES.

A Rumored Consolidation.—As we go to press there is a rumor to the effect that the Fort Wayne Electric Corporation and the Siemens & Halske Company of America, are to be consolidated, the new concern, it is said, to be under the direction of Mr. R. T. McDonald, for many years head of the first named organization under its several names. The consolidated companies, will, it is reported, enter into active competition in all lines of electrical manufacture, it being the purpose, among the extensions, to enter into electric railway work.

The Modern Spirit and Vandalism.—Our London contemporary, *Electricity*, in referring to the deliberations of the municipal authorities of Canterbury, England, on the subject of a public lighting plant, says that it would not be surprised it to learn that when they settle on a site finally for the electric light station, the cathedral will be considered suitable for it! It is led to this opinion by the fact that an ancient castle—apparently Norman—has been converted into a coal-hole for the local gas works, with a modern wooden double gate for coal carts to enter, shoved roughly through a 3-ft. wall. Modern vandals, it is added, are worse than the ancient ones.

Pleasant for the Prisoners.—Our London contemporary *Lightning*, states that several English prisons are to be lighted by elecctricity, and that the inmates are to have the honor of generating the current themselves by means of dynamos attached to a special treadmill, whose points are at present the subject of anxious thought and experiment on the part of experts. It is considered that this would result in a saving to the country and a partial solution of the difficulty of prison labor, which must either be exasperatingly unprofitable—and therefore punishment for its own sake—or a more or less unfair competition with free labor, which suffers in proportion as prison-made wares are put upon the market.

High Voltage Transmission.—A correspondent writes us, *apropos* of the table of high voltage transmission plants contained in Dr. Duncan's inaugural address read before the American Institute of Electrical Engineers (see October issue), that San Francisco is erroneously credited with a direct current power transmission of 1000 HP over 12 miles at 8000 volts, and stated to have been in operation nine years. There is, he writes, a 10-ampere and a 20-ampere motor circuit for distribution around that city, and on the latter a few years ago it was attempted to use 4000 volts, but without success; the dynamo was long since removed from the station, and most of the motors have also been replaced by 220-volt machines. It is also pointed out that Bodie is in Mona County, Cal., instead of Colorado, and that the power transmitted is about 120 HP, instead of 160 HP.

Southern Industrial Journalism.—The 18th annual number of *The Tradesman*, published at Chattanooga, Tenn., contains over 260 pages,and presents a most complete, exhaustive and valuable review of the South, its resources, development and possibilities. Among its contributors are six Southern Governors, the chief statistician of the United States census bureau, twelve leading Southern journalists, twenty prominent Southern chamber of commerce officials, such writers as Edward Atkinson and a score or more of statistical and industrial authorities in their special lines. Electricity is represented by a review of important Southern applications during the year. *Dixie* of Atlanta, Ga., also initiates a new volume with a special issue, that is extremely creditable to Southern trade journalism. The industrial advancement of the South is significantly illustrated by these publications, which are not surpassed by any of their class in the North or West.

Sensational Science.—Referring to an article of the character of those which form the chief feature of the pages of American Sunday newspapers, an English contemporary remarks that it is a pity this misleading claptrap—this kind of scientific sensationalism—should be disseminated among the tens or hundreds of thousands of readers of such publications. The spreading of such erroneous notions about scientific discoveries, it says, is calculated to do a great deal of harm. "We do not mean only to nervous old ladies who may look forward with terror to the time when, to quote the interviewer, 'we shall soon be nothing but transparent heaps of jelly to each other,' and 'I can sit by my own fireside and spy upon the doings of my friends and enemies in their homes two or three streets away.' There is really now a large section of the general public interested in science, and eager for some knowledge of its latest achievements; they ask for bread, and receive a stone."

Power Transmission in Africa.—We learn from our English contemporary,the London *Electrical Review*, that Mr. H. Rider Haggard is chairman of a syndicate whose object is to carry out a scheme to use the water power of the Victoria Falls on the Zambesi River, to generate electricity, and supply it to the various centers of population throughout Rhodesia, either in the form of power to work stamps and mills, or of motive power for other purposes. This scheme had been modelled upon that already achieved at the Falls of Niagara, which,vast as they are, the author of "She" believes to be surpassed in size by the Victoria Falls of Zambesi. This undertaking has been reported upon by Prof. Forbes, who proceeded to Africa for the syndicate during the year of 1895. Subsequently,also, it was favorably reported upon by Dr. Hopkinson, F. R. S., C. E. Our contemporary remarks that, of course, the success of this enterprise is measurable by the success of Rhodesia. If Rhodesia proves a failure, it will fail; if, as most of the syndicate are convinced, Rhodesia proves one of the greatest colonising achievements of this colonising race, this scheme will prove a success.

Incandescent Lamp Lighting Effects.—In a paper on "Decorative Lighting," read by Mr. E. J. Jennings before the Chicago Electrical Society, the author referred to the barbarous arrangement of lights so often met with in public buildings, consisting of lamps in rows so situated with reference to seats as to subject one to a blinding glare. The Auditorium of Chicago is quoted as a "shining" example of this evil. No scheme of lighting, it is added, should be tolerated which causes inconvenience amounting to suffering, as in the base referred to. As a sharp contrast to this, the case is cited of the lighting of the entrance to the Manhattan Insurance Building in New York. As one enters he is aware that the rotunda is well lighted, but how the effect is produced is not at once evident. Upon looking up, however, some large openings are visible in the ceiling, covered with ground glass, behind which are the lights. Upon looking more closely it is seen that these openings are hemispherical, with the lamps arranged so that only reflected light strikes the eyes. The result is a beautifully clear, soft light, that produces an artistic effect and is as a pleasure to the eye.

Polarizing Photo-Chronoscope.—Lieut. G. O. Squier and Prof. A. C. Crehore have recently applied their photo-chronoscope to the study of alternating current. The principle of the apparatus depends upon the polarization of a ray of light when it passes through a magnetic field. Current is passed through a coil surrounding a tube filled with bi-sulphide of carbon. A ray of light is passed through the latter, and as the current varies in value, the angle of polarization of the ray also varies. By an appropriate apparatus, records are taken showing the amount of polarization at any instant, by means of which the value of the current at such instant may be determined. These values plotted give a curve of variation of current. The value of the method in the study of alternating currents is that it provides a continuous record, not involving the movement of any ponderable matter, and, therefore, without inertia in the production of the record. This is the fundamental principle of this chronograph, which gives indications, therefore, in accurate phase with the fluctuating current, no matter how rapid these changes may occur; and since the time scale is also accurately recorded upon the plate by means of a tuning fork, each negative obtained is a qualitative graphical representation of the varying current, automatically plotted in terms of the two variables, time and intensity.

Wiring Calculations.—One of the most useful constants for the electrician to carry in mind is the resistance of one foot of wire having a sectional area of one circular mil, the value of which for commercial copper at usual temperatures is 10.6 ohms. By means of this constant, all of the usual wiring calculations may be made without reference to any other than a table giving the equivalent in circular mils of the commercial wire gauge. In a paper on the "Theory of the Wiring Table", read before the Chicago Electrical Association, Mr. Thos. G. Grier dwelt upon this fact, and illustrated some of the applications in calculating wiring. Suppose, for example, we wish to know the drop on a given line carrying a given current. As the drop is the product of the current and resistance, it is necessary to know the latter, and this can be easily determined without reference to any wiring table; in fact, owing to the arrangement of most of the latter, and their bewildering array of decimals, it is usually preferable to make the following simple calculation: Multiply the length of the line, in feet, by 10.6, which will give the resistance of the line if its area were one circular mil; then divide by the actual area of the line in circular mils,which will give its actual resistance in ohms; multiplying the latter by the current, in amperes, will give the drop in ohms. Suppose the problem is to find the area of conductor for a given drop with a given current. Multiplying the length of wire by 10.6 will give its resistance, were its area one circular mil; multiplying this result by the amperes will give the drop under the same assumption; to find, now, the actual number of circular mils to produce the given drop, the above quantity is divided by the drop in volts, which will give the required area of wire. The reader, if he chooses, can readily put these indications in the shape of formulas, which he will recognize as those given in all wiring handbooks. It is much better, however, to remember the reasoning involved, and thus be independent of formulas.

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Furnace Firing.

The article elsewhere in this issue on mechanical stokers and shaking grates should be found of interest by all steam users, and particularly by those who have not availed themselves of modern appliances to supersede hand firing of boiler furnaces. Mechanical feeding and working of furnaces have such incontestable advantages, both in economy of coal consumption and regularity of steam production, that no steam user can be considered up to date who is lacking the necessary equipment to attain these desiderata. With a small boiler plant served by a cheap fireman, it might not pay to use a mechanical stoker, but in a plant of any considerable size the reverse would undoubtedly be the case, as the labor thereby displaced would more than justify the employment of a man with the necessary skill to place in charge of the stokers. This skill need not be of a very high order, so that the saving in the item of wages alone due to the labor displaced, would be large. As to shaking grates, the requirement of skill beyond that possessed by the average fireman does not enter, so that in this case no complication whatever enters to serve as an excuse against their adoption.

Danger from Röntgen Rays.

A considerable number of cases have been reported of painful and, in some instances, serious effects from exposure to Röntgen rays. In all of these cases the exposure was for a considerable length of time, but as the danger limit has not yet been determined, it is well for experimenters to be cautious. In a recent instance a hand was exposed for five minutes in each of three different positions—palm up, palm down and palm vertical—and some days after burning sensations were experienced which, however, passed away several days later without any other effect. Prof. Elihu Thomson at a recent meeting of the American Institute of Electrical Engineers related his painful experience from an exposure of a little finger for a half-hour to the influence of the rays. Nine days later the finger became much inflamed and shortly after the skin peeled off, leaving the flesh bare; healing was extremely slow, the finger being still in a bad condition six weeks after the experiment. Newspaper accounts have described cases when the suffering was extreme, ulcers forming over considerable portions of the body; in one case reported, the sight of an eye was threatened, while loss of hair when the head was exposed to the rays has been of common occurrence. As the physiological action of the rays is not known, it cannot be readily assumed that their ill effects are necessarily confined to the surface exposed, and therefore caution should be observed in subjecting internal organs of the body to their influence for considerable periods.

Inductance.

In another column will be found an article on inductance in relation to one of its practical aspects. The word "inductance" is one of the many new terms introduced with alternating currents, and a knowledge of the phenomenon which it designates is necessary to even an elementary understanding of alternating current working. In point of fact, the understanding of inductance is quite simple if three elementary conceptions are kept in mind: First, that every circuit carrying a current encloses lines of force. Second, that if a constant E. M. F. is introduced into a circuit, part of the energy of the resulting current first goes toward generating these lines of force, and the current therefore requires time to reach its normal value. Third, when an E. M. F. is removed by short-circuiting or breaking a circuit carrying a current, the lines of force which accompanied the current leave the circuit and in so doing cut it, thus generating an inductive E. M. F.; if the original E. M. F. is removed without breaking the circuit, the inductive E. M. F. will create a current of its own in the circuit in the same direction as the original E. M. F., thus gradually tapering off the former; if the circuit is broken, all of the lines have to pass out before the rupture is electrically complete, thereby generating an E. M. F. that may be extremely high if the time of electrical rupture is very small. In the present issue the subject of inductance is considered with reference to the rupturing of a direct-current circuit, and in future issues it will be treated with reference to alternating currents.

Retrospective and Prospective.

With the commencement of the second volume of the AMERICAN ELECTRICIAN, we may be pardoned for referring to its record for the past eight months—a record which, if the increase of a subscription list is a criterion, has been unprecendented in the history of electrical journalism. The extent of that increase may be appreciated from the statement, which can be amply justified, that the AMERICAN ELECTRICIAN starts the new year with a paid subscription list not only larger than that of any other electrical journal in the world, but exceeding the combined paid subscription lists of all other electrical periodicals in the United States. This success can only be ascribed to hearty appreciation by the electrical public of the manner in which the AMERICAN ELECTRICIAN has redeemed the promises set forth in the initial number—to supply practical information for practical men, and keep its readers abreast the very latest developments in the electrical field, both practical and scientific.

Far from there being any intention to rest upon the record thus achieved, the earnest endeavor will be to constantly increase the value of the pages of the AMERICAN ELECTRICIAN to its readers. During the

year a number of new features will be introduced, among which will be a series of articles on typical central stations of the world, now in course of preparation by authoritative writers. As in the past, particular attention will be paid to alternating currents, which will be treated so as to place their understanding within the reach of all, yet without sacrifice of completeness of presentation. While giving minute attention to the purely electrical details of the various branches of electrical engineering, their mechanical features will continue to receive the recognition which their great importance in practical work demands. As in the past, the pages of the AMERICAN ELECTRICIAN will be absolutely devoid of padding and mere perfunctory articles. With its practical departments in charge of men of practical experience and recognized standing as experts, with the current developments in electrical science simply treated in its columns by accepted authorities in the various branches, and the advances in practical engineering summarized by competent writers, the advantages offered to the reader of these pages will continue to be unique.

Theory.

The word theory has come to have a diversity of meanings, some of which are more or less to its discredit. Strictly speaking, a theory is merely a generalization based upon definite and well founded facts, and is strictly limited in its application to the scope of these facts. Popularly, theory is confounded with hypothesis and speculation, and often with the maunderings, interspersed with scientific phraseology, of downright ignorance. One may, through analogy or otherwise, but without the support of definite facts, conceive of an explanation of a certain phenomenon—in other words, found a speculation concerning it. Reinforced by a few facts, he may build up a working hypothesis, by means of which he can extend his investigation of the phenomenon. Should the hypothesis stand the test of all the known facts bearing on the phenomenon, and should the number of these facts be sufficient to justify the generalization involved, it passes finally into a theory. Still another abuse of the word theory, and the one perhaps the most prevalent, is that which arises from its misapplication through ignorance of its full bearing. For example, we sometimes hear that the theoretical points of commutation of a dynamo are on a line passing midway between the gaps of a bipolar machine. The true theory of commutation, of course, limits the above statement to the condition of open circuit alone, on closed circuit taking into consideration armature reaction, self-induction of armature coils short-circuited by the brushes, saturation of pole horns, etc. Again, we hear of the theoretical efficiency of the steam engine, when what is meant is the efficiency in an ideal case, which theory itself teaches us cannot be approached in practice.

Of all offenders in the misuse of the word "theory" and "theoretical," the steam engineer of the old regime, we believe, easily ranked first. Were we asked to name the profession, the members of which, in conversation and writing, have been most addicted to theorizing, the answer would be, without hesitation "steam engineering." We say "in conversation and writing," for it was one of the peculiarities of the case that when it came to practice the class to which we refer invariably gave a cold shoulder to the theories in which they otherwise took so much pleasure. The reason for this appears to have been twofold. In the first place, as one of the oldest of the professions, the traditions of steam engineering extend back to the time when personal authority in matters scientific reigned supreme—when mere dicta, if from an authoritative source, had the weight of absolute fact. A consequence of this was to give the mere opinions emitted by those occupying a prominent position in the profession an unwarranted weight, and to encourage imitators to pose in turn as oracles. The other extreme of this condition, it may be added, is met with in electrical engineering—the newest profession—in which the utterance of authority is given little or no weight aside from the facts concerned. In the second place, heat being, unlike electricity, an undirected force, its phenomena are elusive as to direct determination and exact measurement. Consequently, much speculation and hypothesis under the name of theory may be indulged in without the fear of being met with the direct contradiction of fact. It is, however, a curious fact—though perhaps a natural consequence—that by no class was established theory and the professor of theory regarded with greater contempt than by the steam engineer of the *ancien régime*—the influence of which period has perhaps not yet entirely passed away.

Electric Traction Under Steam Railway Conditions.

A recent number of the Transactions of the American Institute of Electrical Engineers contains a voluminous, able and interesting discussion on the applicability of electric traction to steam railways for general service. The consensus of opinion among the many engineers who took part in the discussion was, that there is no probability of electric traction being thus applied in the near future if present conditions as to general railway traffic are maintained. All of the speakers, however, who referred to the applicability of the electric system to those cases where the service is frequent and where light trains may be used, were sanguine of great extensions of electric traction in that field. Under this head come railways like that now operated at Nantasket Beach, and also what may be called a mixed system, or electric cars on steam lines to handle the local traffic now taken care of by steam trains running at intervals of a half hour or less from our large cities. The field thus conceded is so considerable that, though some of the more ambitious spirits may chafe at any limitation placed on the possibilities of electric traction, even if but a provisional one, this branch of the electrical industry need not for years yet feel any check.

In the discussion several speakers spoke of the advantages of electric over steam traction for very high speeds. According to some of the figures offered, electricity for trunk service could not compete with steam, either with respect to fixed charges or operation, but these figures were based upon ordinary and not special service. Aside from the question of roadbed, there can be no doubt as to the practicability of the electric locomotive for very much higher speeds than perhaps have been thought of in connection with the steam locomotive. If, therefore, high speed would pay—if there should be demand for very rapid service—the question of cost would assume a secondary importance, the case being similar to that presented in ocean traffic.

It is well known that of two transatlantic ships having the same freight-carrying capacity, but one crossing the ocean in six and the other in ten days, the former will represent an investment four or five times greater than the latter, on account of the increased size of vessel necessary to carry the greatly increased amount of machinery, and the increased cost of the latter. The expenditure per trip in labor and coal, for the same reason, will be somewhere near the same proportion, or considerably larger than the square of the ratio of the speeds. Yet this enormous increase in investment and operating expenses has been found to pay, and the disproportion is being yearly increased with profit. In view of this experience in ocean travel, it is as irrational to make disadvantageous comparisons as to the cost of high-speed railway service on the basis of usual operating expenses and investment, as it would be to compare, on a freight-carrying basis, the economic performance of the "St. Louis" with that of a tramp steamer.

HOW TO MAKE AN INDUCTION COIL.

BY GEORGE T. HANCHETT.

Since the advent of the Röntgen discovery the induction coil has risen to a much more prominent place as a scientific and practical instrument. It has very naturally been greatly improved in its construction within the past year, but inasmuch as these improvements are not generally known and used, the writer has presumed to believe that a description of them may be interesting.

The basis of the discussion will be the construction of a six-inch spark coil, but it may be profitably remembered that the average induction coil built in sections, may be thus rebuilt, and oftentimes the length of

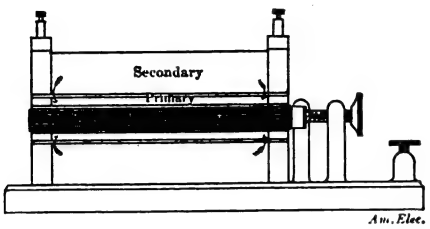


FIG. 1.—SHOWING LEAKAGE FROM SECONDARY TO PRIMARY.

spark it is capable of giving thereby trebled, even though thirty or forty per cent. of the secondary is removed in order to accomplish the construction.

Many modern coils are built on lines that make extensive internal leakage a great possibility. Some coils are made with as much as twenty-five pounds of wire in the secondary and yet under the most favorable conditions the spark obtained is but six inches in length. The makers of such coils broadly claim that it is impossible to break down the insulation of their apparatus, but in view of the fact that a six-inch coil can be made with a five-pound secondary, it is easy to see that the coils just referred to are broken down already, and that it is a case of spoiling a bad egg—a manifest impossibility.

The principal leak in an induction coil is from the secondary to the primary, as is shown in Fig. 1. Between the points of leakage indicated the full difference of potential of the coil exists. The 1/8 in. of hard rubber and the almost negligible air gap usually provided can scarcely be expected to withstand the E. M. F. that will urge a discharge across a six-inch air gap.

A second source of leak is shown in Fig. 2, and exists at the separator pieces between sections. The insulation between the primary and secondary is broken in its continuity by these pieces, and as it is impossible to make an electrically tight joint, such insulation as is provided is no more effective than an equivalent gap of air. The insulation between primary and secondary must be a continuous homogeneous mass, and sufficiently thick to withstand the maximum E. M. F. of the coil. Fig. 3 illustrates the ideal method of insulating a secondary section. The spaces, *SS*, are to be filled with paraffine or some equivalent continuous insulator.

Covered wire for an induction coil is not necessary, and the use of silk wire is a most expensive construction, from which absolutely no advantage can be gained. One way is to use bare wire, winding a thread between adjacent turns, as shown in Fig. 4. Colored thread should be avoided. The space between the layers should be at least four or five times the thickness of the insulation between the turns. The insulation between the turns of an induction coil is about 5 mils (.005 in.) thick, and experience has shown that this is none too much. A space of 1/64 in. can be used between the layers to advantage. This space should be filled with absorbent paper that will readily soak up paraffine wax.

Fig. 6 shows a regular sectioned dimension drawing of the 6-in. spark coil already referred to. It would be idle to enter into a long dissertation on the various features of this coil that are common to every instrument of a similar nature, and only the novel ones will be discussed, and the quantitative measurements given. The secondary coils are constructed of bare wire, absorbent paper and cotton thread, substantially as indicated heretofore. Care is taken in the winding to keep away at least 1/4 in. with the wire from the edge of the paper layer, partly for the added insulation between the layers and partly to prevent the annoyance of the end turns slipping out when handling the section. If an old coil is being rebuilt, it will not pay to thus rewind it. Sufficient wire from the inside of the secondary sections should

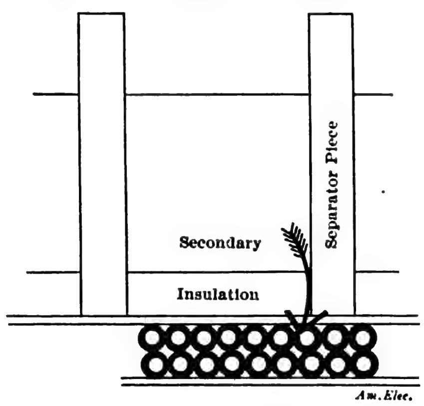


FIG. 2.—LEAKAGE THROUGH JOINT.

be removed to admit of reassembling it as per drawing, a comparatively easy thing to do, and the results will be nearly as good as with the coil here described.

The great feature of the coil is the method of supporting and insulating its primary and secondary. A long box is constructed as per drawing, and from the geometrical center of the ends is supported the tube that forms the enclosing envelope for the primary coil and its core. The secondary coil is divided into six sections, each supported on a piece of hard rubber tube with end collars of glass or hard rubber This hard rubber tube allows 1/4 in. in the clear between its interior surface and the primary envelope. The glass collars are square, and are of such a shape that they just fit the inside of the box, and in their lateral dimensions are a perfect measure of its interior section. The space between adjacent sections is 1/4 in., and between the last coils and the end pieces, 1/2 in. is provided. The coil is wound to a diameter of 6 ins., the internal dimensions of the box surrounding it being 8 ins. square.

Before assembling, the coils are boiled for a long time in paraffine, and are removed therefrom only when the wax has cooled sufficiently to attain a mushy consistency. They are preferably assembled while in this state, for large soft clots of wax adhere to the coils and close in on the bobbin on which the coil is put, thus filling up objectionable air spaces. The assembling of the coil being complete, each secondary will be mounted on a tube in the box and will rest in a partition made on two sides of glass or hard rubber. Nowhere will any secondary section have any connection with any primary setion or with an adjacent secondary section except through paraffine wax in a continuous mass that cannot be broken down unless penetrated. The great merit is the continuity of the insulation and the entire absence of joints. To attain this result, the box must be filled with boiling paraffine at all partitions; thus filling up all the air spaces, of course, first making the proper connections. The top of the box is then put on and the paraffine is allowed to set. In setting it will shrink a certain amount and this space must be filled with more paraffine.

The coil is to be mounted on a box containing the condenser in the usual way. It will be well to divide the condenser into sections, as shown in the diagrammatic connections of Fig. 5. If the coil is to excite a Crookes tube, this is an important matter. Some tubes that are capable of giving admir-

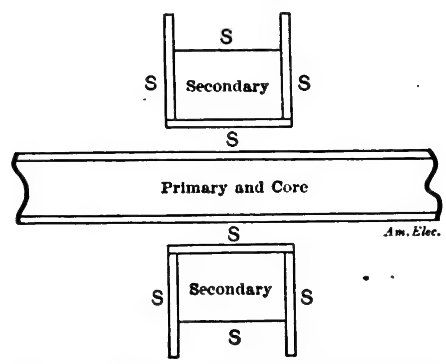


FIG. 3.—IDEAL INSULATION FOR SECONDARY SECTION.

able results often signally fail to do so on a coil of great capacity, but will operate perfectly on a smaller one. The reason of this is found in the fact that the large coil may

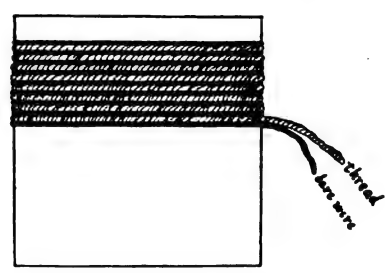


FIG. 4.—SHOWING HOW BARE WIRE MAY BE USED.

not be in as close resonance with the tube as the smaller one. By the use of the variable condenser, the resonance of the coil can be varied in pitch and its range of excitation of tubes widened materially. The principal dimensions of the coil just described are as follows:

Primary coil. Two layers of No. 12 B. & S. wire, single cotton covered, wound on a fibre

tube and surrounded with a hard rubber enveloping tube, as per drawing.

Secondary coil. Five pounds of No. 36 B. & S. bare wire, wound in six sections, as shown and described.

Support. A mahogany box supporting primary envelope, and glass partitions, as described and shown.

Condenser. Seventy-five sheets of tin-foil 7 ins. $\times$ 9 ins. alternated with sheets of paraffined paper 8 ins. $\times$ 10 ins.

A word about the secondary connections may not be out of place because of the confusion that has arisen among amateurs. It is customary to wind the secondary coils exactly alike with the outer lead on one flat face and the inner lead on the other. If such

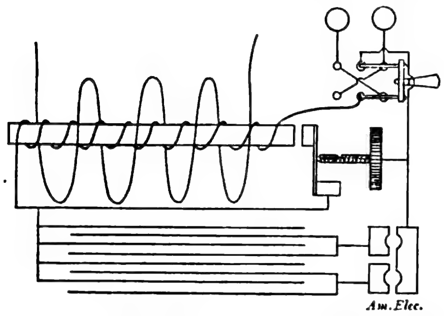


FIG. 5.—DIAGRAM OF COIL CONNECTIONS.

similar coils are slipped on the core in the *same way*, it will be necessary in order to connect them in series to join the inner end of one to the outer one of its next neighbor. This will require that the connecting wire must be brought up between sections and in this position it will be very difficult to insulate. Therefore the coils are slipped on in

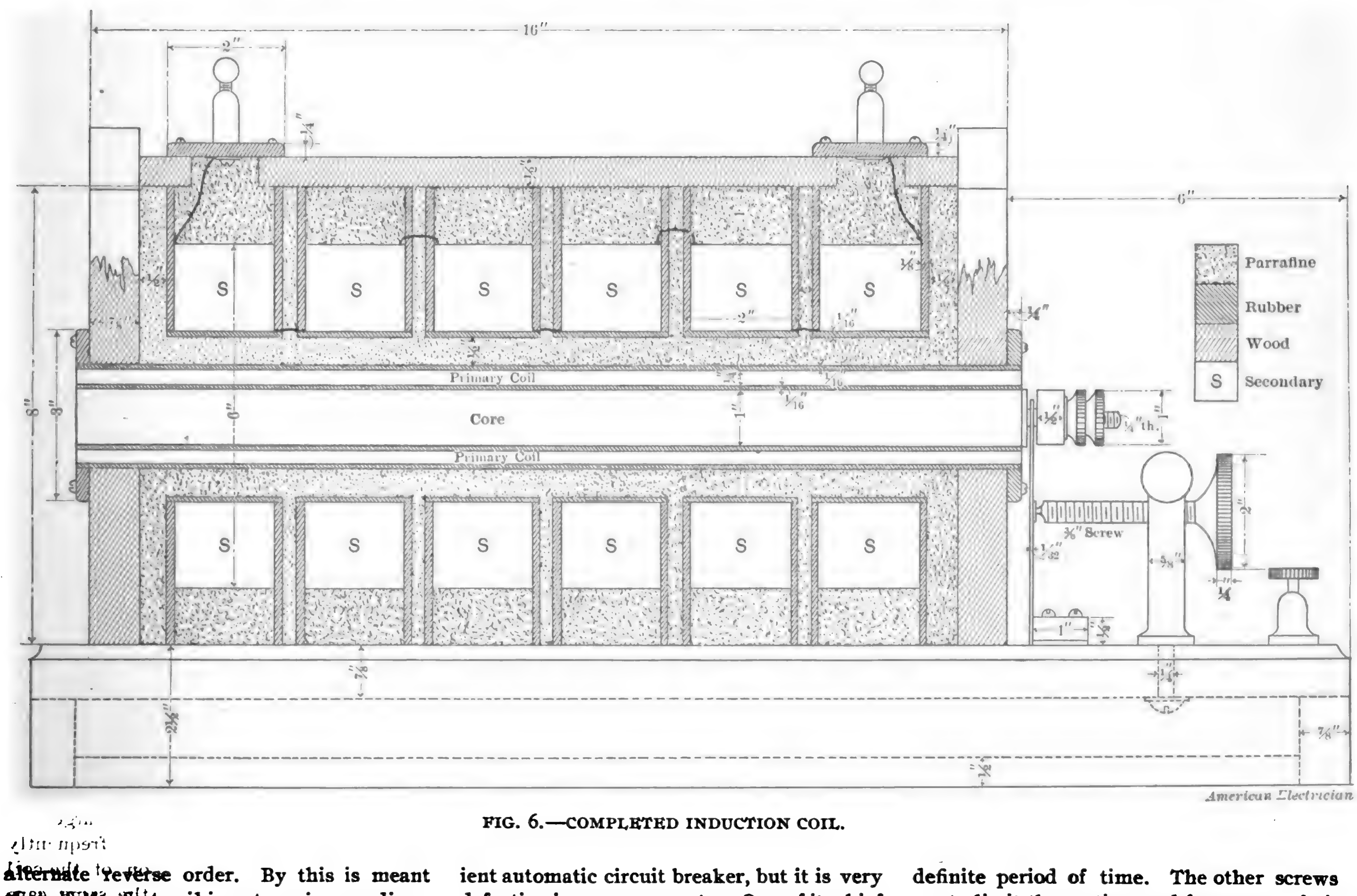


FIG. 6.—COMPLETED INDUCTION COIL.

alternate reverse order. By this is meant that if the first coil is put on in one direction, the next is put on so that similar ends face each other. To connect the coils so placed in series, the *like ends* must be connected. A moment's inspection of this connection will show that the current travels

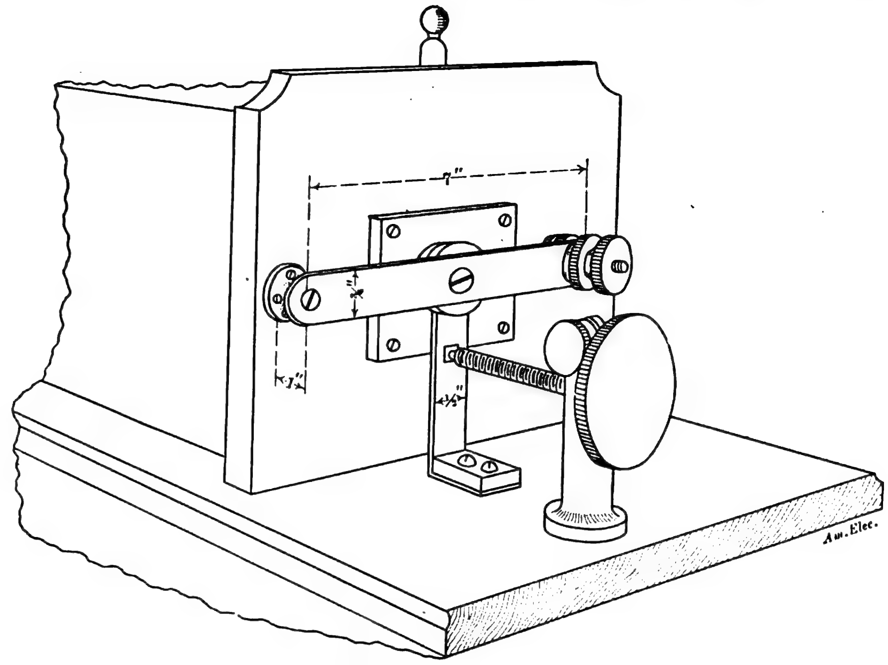


FIG. 7.—PERSPECTIVE OF VIBRATOR.

about the core in the same direction through all bobbins, and that the arrangement does not connect the bobbins in opposition, as has been popularly supposed.

The circuit breaker or interrupter is one of the most important parts of the coil and little has been done to improve it. The ordinary vibrator is perhaps the most convenient automatic circuit breaker, but it is very defective in many respects. One of its chief faults is that it keeps the circuit open too long and closed for so short a period that the core does not have time to fully charge or the current to attain its full value. An interesting modification that tends to achieve this result is shown in Fig. 7 and is drawn in suitable form to apply to the coil just discussed. Its principle is as follows: The spring, C, presses tightly against its contact, K, at all times except when it is struck by the hammer of the vibrator, when contact is broken for an instant. Thus the break is instantaneous and the make is a definite period of time. The other screws are to limit the motion and frequency of vibration of the hammer.

As indicated in the illustration, a double-pole switch and a means of varying the condenser are to be placed on this induction coil. A double-pole double-throw baby knife switch is the most suitable for the reversing device, and for the condenser a pair of plugs and plates will be found convenient. These are not shown on the drawing because they would tend to confuse the more important details of the vibrator. It is obvious that they should be placed in a convenient and symmetrical position and that further mention of them would be more perfunctory than interesting.

It will be noted that this coil is designed on lines that seem to directly defy all laws of magnetic efficiency with regard to the distance between primary and secondary. Many might hesitate before spending their time and money on such a construction. The reader is assured that the dimensions herein given are the result of a series of progressive experiments, and each coil in the series was constructed with the idea of improving the last. Not until the liberal insulation shown was adopted were maximum results obtained and even now the advisability of carrying the principle further is being considered. The smaller amount of wire and its inferior magnetic position are more than compensated by the absence of leakage and, moreover, the extremely low internal resistance of such a coil enables it to produce a much more highly calorific spark or, as it is commonly termed, a fatter one, than if the older and more conventional construction were followed.

INTERIOR WIRING.

THE ROTARY BALANCE COIL.

It sometimes occurs that a three-wire system is used in interior wiring not having a main neutral, the transformation being effected by the use of a special apparatus connected across 220-volt mains. This apparatus is called variously an equalizer, a dynamotor, etc. None of these names seems to the writer appropriate, for they are already used to designate apparatus of a totally different nature and duty. Accordingly the name "rotary balance coil" is suggested as an appropriate name, for it at once suggests the static balance coil used in alternate current wiring whose office and method of filling it are precisely analogous. This article will be devoted to the principles of the rotary balance coil and its applications in practice.

If two 110-volt motors be connected in series across 220-volts and be required to do no work other than revolve, little current will be used, due to the back E. M. F. of the machines. If the fields of the two be adjusted to the proper value, the motors will revolve at the same speed, and connecting their shafts mechanically will make no difference in the operation of the system. We shall then have the arrangement diagrammatically shown in Fig. 1.

Now if a third wire is brought out from the common connection of the two motors, it will form a neutral for the two outer mains, and the system may be unbalanced until the difference in load equals the capacity of the rotary balance coil, and this without practically altering the equality of the voltage on either side of the system. It remains to be seen how this combination of motors just referred to accomplishes this result.

Let us suppose that we have sixty lamps on the system, forty on one side and twenty on the other, which call for currents of twenty and ten amperes, respectively. The total watts to be supplied must then be 3300, and at 220 volts this calls for a current of 15 amperes from the mains—five too many for one side of the system and five too few for the other.

The function of the rotary balance coil is to divide this energy suitably between the two sides of the system and maintain the pressure of both at 110 volts. This is accomplished by the action of B as a motor with five amperes input driving A as a dynamo with five amperes output. These currents combine, as shown in Fig. 4, and produce the correct currents in the appropriate circuits.

The next question is as to just how the unbalancing of the load makes the proper machine act as a dynamo driven by its mate as a motor. It is found in the following reasoning. Unbalancing such as described tends to lower the voltage impressed on A, and raise the voltage impressed on B. Obedient to the laws governing the speed of motors, the speed of B slightly increases, dragging A along with it, as the two are mechanically coupled. The slightly increased speed of A, coupled with the slight diminution of the E. M. F. impressed upon it, makes the E. M. F. that it generates greater than that opposing it and it therefore becomes a dynamo and delivers current into the local circuit, $a\ b\ c\ d$, supplementing the current from the mains. This is illustrated in Fig. 2. Similarly, the motor abstracts five of the fifteen amperes from the mains, shunting it by the smaller group of lamps and delivering it to the larger and uses it in transit as power to drive the dynamo. The motor circuit is shown in Fig. 3 and the combination of all the circuits is shown in Fig. 4.

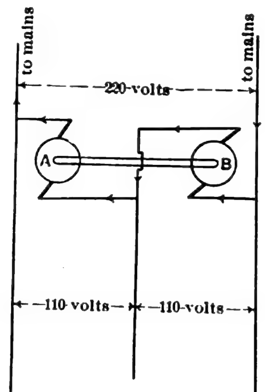


FIG. 1.—CONDITION OF BALANCE.

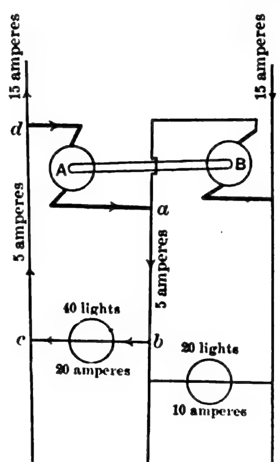


FIG. 2.—SHOWING DYNAMO CIRCUIT.

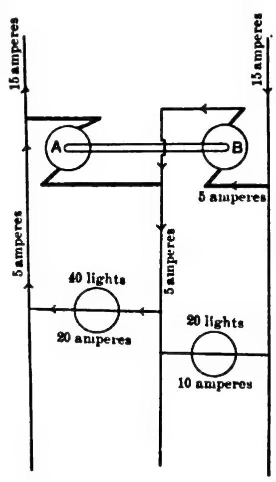


FIG. 3.—DIRECTION OF MOTOR CURRENT.

If the system is perfectly balanced, both machines will operate as motors, taking just enough current to turn them over.

It may be remarked that the output of the mains is slightly in excess of that required by the lamps, the difference compensating for the losses of the motors. If, however, the efficiency of the latter approaches ninety-five per cent., the efficiency of the system compares so favorably with an ordinary three-wire system representing the same money value, that the rotary balance coil is frequently profitably adopted.

An interesting and practical modification of this device is the combining of the two machines in one. This is accomplished by building an armature with two distinct windings upon it, each connected to its own commutator at either end of the core. Thus the windings utilize the same magnetic circuit and the same armature core, and therefore they act in harmony and normally tend to drive the rotating part at the same speed. The field is usually excited from the 220-volt mains and needs no adjusting device.

This construction has many advantages. The losses of the apparatus are almost divided by two, and the floor space is greatly reduced. The machine is absolutely sparkless at all loads—a common claim—but in the case of a rotary balance coil susceptible of ample verification, for every wire on the armature carrying current in one direction there is a mate adjacent carrying an equal current in the opposite direction. Therefore the armature has no demagnetizing tendency and the line of commutation remains fixed. A good example of a rotary balance coil is shown in Fig. 5, which shows a machine of this kind made by the Excelsior Electric Company, of Brooklyn.

The size of the rotary balance coil depends upon the average unbalanced condition of the system. It is obvious that they are limited in capacity and will cease to take care of circuits after the difference in load between them exceeds their rating. A popular figure is to have the balance coil equal to ten per cent. of the capacity of the circuits it is to regulate. This is a most liberal figure, but a very suitable one for circuits which have a motor load, or use searchlights. For circuits using lights only, the unbalancing rarely exceeds three per cent. if the system is properly subdivided, and on such circuits it is obvious that smaller sizes can often be advantageously used.

Rotary balance coils seldom come within the scope of an interior wireman, unless the building he is working upon be a large one, but in such buildings they are frequently used. The permanent position of the coil must be chosen with much the same care that is exercised in the location of a dyna-

mo electric machine. It must be a clean, dry place, free from dust and flying particles and the machine must be supported in such a way as to prevent its vibration from being objectionable. Daily inspection is desirable and conduces to much better operation, but the rotary balance coil as a rule requires far less care than the ordinary dynamo.

If the rotary balance coil be driven from an outside source of power, it will operate as a three-wire dynamo, but it is not as satisfactory as two machines, as the varying load demands different fields for the two windings.

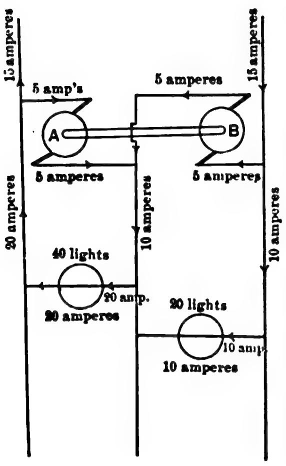


FIG. 4.—COMBINATION OF DYNAMO AND MAIN CIRCUITS.

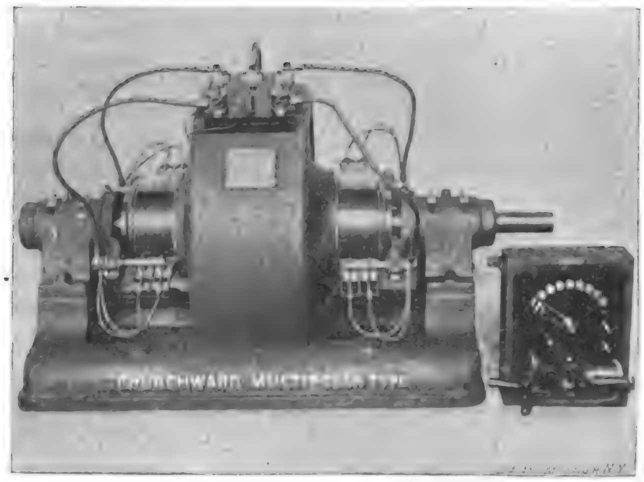


FIG. 5.—ROTARY BALANCE COIL.

FAULTS AND HOW TO FIND THEM.

FAULTS IN TRANSFORMERS.

The transformer is, generally speaking, the most inoffensive part of an electrical installation. It rarely harbors faults and seldom gets out of repair. When difficulty does occur, however, it is particularly aggravating on account of its evasive nature, and often highly dangerous. These troubles divide themselves into the following classes:

Grounds and short circuits on the primary; grounds and short circuits on the secondary; open circuits on the primary; open circuits on the secondary; interconnection between primary and secondary; imperfect magnetic circuit; improper connections. These faults will be taken up in order.

A ground on the primary, of course, immediately tests out with a magneto. It will be evidenced by a partial ground on the line on a wet day, the pole then becoming conducting. This, however, is by no means conclusive evidence of a grounded transformer, for it is plain that other causes will produce the same result. The faulty transformer will usually disclose itself by poor regulation or notable drop in voltage, and it should then be relegated to the repair shop. Once there, it becomes a matter of locating the trouble and repairing it with the least labor. Taking first the case of a grounded transformer, it is easy to locate the fault electrically by a bridge method similar to that used in the testing of armatures, but this would give absolutely no clue to the actual location of the fault because of the general distribution of the internal circuit.

The most satisfactory way is to set the transformer up for unstacking its laminæ, as shown in the illustration, and connect as indicated to an electrical circuit. It will be seen that the bell, *A*, is short-circuited by the transformer fault and will ring when the latter disappears. After slacking off the bolts or other device that loosens the laminated construction, the latter should be tapped all over with a babbit hammer and it is probable that the plates in contact with the electrical circuit will be moved and the short circuit be momentarily broken, as will be announced by the ringing of the bell. This locates the fault and points out the most rapid way of reaching and remedying it. In case that the fault does not disclose itself thus easily, the transformer should be unstacked, still connected as shown. The moment that the last grounded lamination is removed, the bell will begin to ring and the accurately located fault can then be corrected as judgment may direct. Further unstacking is thereby rendered unnecessary. The battery, *A*, should be of the blue vitriol or other type of closed circuit cell.

A short circuit in the primary is evidenced by a drop in voltage and an increased leakage current at no load. If a large portion of the primary be short-circuited, it will be impossible to keep a fuse in the primary fuse box. There is no convenient way of locating the short-circuited coils, but care should be taken not to dismantle the transformer unless the nature of the difficulty is certain. To this end it will be well to measure the resistance of a good transformer of the same size and make, and compare it with the resistance of the faulty one. Make a table of these resistances as they are measured, for future reference. If the resistance of the faulty transformer is less than that of the good one, a partially short-circuited secondary may reasonably be expected.

In case that the proper resistance of the transformer is not known and there is no good one of the same make and size for comparison, the proper primary resistance can be calculated from the resistance of the secondary. In all good step-down transformers the primary resistance is equal to the secondary resistance multiplied by the square of the transformation ratio. Thus, if a transformer transforms from 1100 volts to 110 volts the ratio of transformation is

$$\frac{1100}{110} = 10.$$

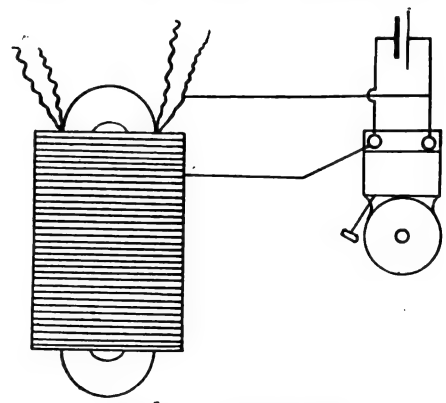
Supposing now that the resistance of the secondary is .1 ohm, the proper resistance of the primary would be $.1 \times (10)^2 = .1 \times 10 \times 10 = 10$ ohms. If the transformer should test out a seven ohm primary, it would be probable that the latter is partially short-circuited. If large numbers of transformers are to be tested, the table of resistances of standard sizes will be indispensable.

A ground on the secondary should be treated in much the same way as a primary ground, but a secondary short circuit has points of difference by which it may be distinguished from primary short circuits, although the general symptoms are much the same. The voltage falls off and the primary fuses blow, but there is no increase of the no-load leakage current as in the case of the short-circuited primary. The short circuit may be estimated by the method of comparing resistances already explained. Short-circuited portions of secondary coils are liable to burn out while the portions not short-circuited remain intact. The reverse is the case in an internal primary short circuit.

Open-circuits on either primary or secondary are immediately evidenced by the failure of the transformer to operate. They are readily detected with a magneto bell.

Such accidents and faults as have just been enumerated are usually the result of a lightning discharge, and frequently all of the faults occur at once. The usual effect of a lightning stroke on a transformer is to burn large holes in the primary and by the melting of numerous wires together, create almost all of the results recited. The secondary coil often escapes without injury.

Interconnection between primary and secondary is a most dangerous fault because it brings the primary voltage into private houses and the systems of interior wiring to which the transformer may be connected. It is doubly dangerous, because it often gives no warning of its presence, the lights operating to all appearance as usual. Such faults should be periodically tested for by cutting out a line during the day and putting the primary feeders to earth. All the dependent transformer stations should then be visited and rung up to earth with a magneto. Those stations that do not ring clear of the ground should be most rigorously



TESTING TRANSFORMER.

tested for this most serious fault. Its repair necessitates the dismantling of the transformer in any event, and little labor can be saved on that score.

In putting the transformer together, an error is liable to be made that will cause the transformer to regulate very poorly, especially as the load comes on. Both coils will test out free of grounds and of the right resistance, but still the fault will exist. This fault is an imperfect magnetic circuit, and is rather a blunder than a fault. In some transformers the laminations lap instead of butting together in forming their circuit of iron about the coils, and the mistake is sometimes made of covering the surfaces that are to lap with paper. This breaks the magnetic continuity and increases the leakage current and is detrimental to the regulation. In placing the laminations around a transformer, the insulation between them should be such that an electrical current could flow through the iron *around* the coils with great ease, but would be absolutely prevented from flowing in a direction parallel with the coils. If this rule is faithfully followed, the magnetic circuit of the transformer will be as good as it can be made with the set of punchings used.

Improper connections are also the work of a novice. They are evidenced by the transformer refusing to operate at all and perhaps burning out, or by its operating at one-half the rated voltage, or perhaps by an undue falling off of voltage before the transformer is fully loaded.

In most modern transformers the secondary is divided into two coils, and often the primary coil is thus subdivided also. This is to enable the transformer to be connected to mains of various voltages, and to supply current at various voltages as well. The common arrangement is to so connect the secondary that it has two coils and four terminals. If these coils are connected in series the voltage will be 110. If in multiple 55. This seems simple enough, but amusing mistakes are sometimes made. Of course, a transformer connected for 55 volts could not be expected to deliver a pressure of 110, but that is sometimes disregarded by novices who look for poor contacts or similar faults instead of consulting their transformer connections. The converse mistake is equally amusing, that of connecting up for 110 volts and expecting 55. For an instant every lamp emits a blinding glare of light and suddenly blackness ensues, due to the blowing of the transformer fuse. This usually thoroughly scares the novice and often burns out many lamps. It is a very expensive mistake to make, but its remedy is obvious.

Sometimes the two secondary coils are close-circuited in series in the effort to place them in multiple. This results in the instant blowing of the primary fuse, and it will blow as often as it is put in. Having made sure that there is no external short circuit on the secondary, reverse the terminal of one coil and try again. Sometimes the transformer is connected up correctly for 55 volts, but only one of the secondary coils is connected in. This will result in a reduced voltage if the load becomes at all heavy, and can, of course, be remedied by connecting in the idle coil. If the primary coil is subdivided, the same mistakes are liable to be made and the results produced are very similar. Some transformers are so arranged that improper connection is impossible, but, of course, none of them can be arranged to prevent the throwing of 110 volts on a 55-volt system or *vice versa*. There the electrician is left to his own tender mercies.

AMERICAN TELEPHONE PRACTICE.

BATTERY TRANSMITTERS.

BY KEMPSTER B. MILLER.

Many vain attempts have been made to discover a satisfactory substitute for carbon as the variable resistance medium in telephone transmitters, the patents on the use of carbon electrodes having, until recently, formed one of the mainstays of the American Bell Telephone Company's great monopoly.

The theory of the action of carbon in the transmitter has been the subject of much discussion. Its peculiar property of changing its resistance under varying pressure is undoubtedly accountable for a large part of its wonderful action. As previously pointed out, any motion of the diaphragm increasing the pressure between the electrodes lowers the resistance between them, thus allowing the passage of a greater current. A decrease of pressure produces the opposite result.

Probably an even greater factor in the action of the microphone is the variation of the area of contact between the electrodes, due to the varying pressure. If a billiard ball be gently pressed on a plain marble slab coated with graphite, the area of contact of the ball with the slab will be indicated by a small dot of graphite on the ball. If, now, the ball be dropped from a considerable height it will be noticed that the spot of graphite on the ball is much larger, showing that the ball has flattened out to a considerable extent, owing to the greater pressure exerted. This simple and familiar experiment demonstrates clearly the variation in area of contact between two bodies, due to variations of pressure between them. Of course, if the two bodies are conductors of electricity, the resistance between them will vary inversely and the current directly as the area of contact.

Another peculiar property possessed by carbon is that its electrical resistance decreases when its temperature is increased. This is directly opposite the action of most other conductors. It has been argued that the microphonic action is due in part to the fact that an increase of current (due to increased pressure and diminished resistance between the electrodes) causes a slight heating at the point of contact; that this heating causes a still further diminution of resistance with an additional increase of current; and that conversely a momentary decrease of current causes a decrease of temperature with a corresponding additional increase of resistance and diminution of current. The very fact, however, that the increase of current is needed to cause the rise of temperature seems to preclude the supposition that the rise of temperature should cause the diminution of resistance with its corresponding increase of current in time to do any good. The heating effects in carbon are comparatively slow, and it would seem that the changes in temperature would lag slightly behind the changes in current producing them, in such a manner as to be detrimental to telephone transmission.

This property of carbon of lowering its resistance with increased temperature is, however, important in that when the transmitter becomes warm from constant use its resistance as a whole is decreased. When the transmitter is heated the total resistance of the circuit is lowered, and the changes in resistance produced by the sound waves therefore bear a greater ratio to this total resistance with corresponding increase of efficiency.

It is certainly most fortunate that this substance, exhibiting to a more marked extent than any other the property of varying its resistance under varying pressure, also possesses the desirable property of lowering its resistance when heated, and is elastic, non-corrosive, cheap and easily worked.

The form of transmitter almost universally used in this country up to within a few years ago, and still largely used, is that devised by Francis Blake, of Boston. This instrument is shown in Fig. 1, in which *B*

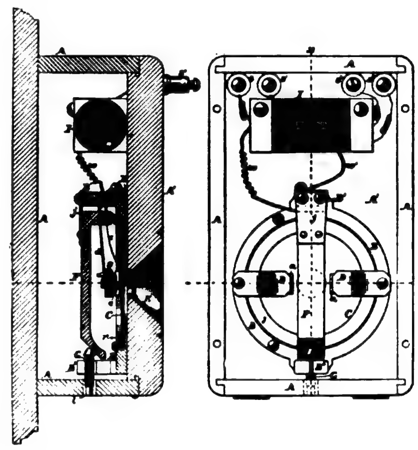


FIG. 1.—BLAKE TRANSMITTER.

represents a metal ring or frame for holding the mechanism of the instrument. It is screwed to the cover, *A′*, of the box, *A*, and has two diametrically opposed lugs *B′ B²*. On this ring is mounted the diaphragm, *C*, of rather heavy sheet iron, supported in a rubber ring, *r*, stretched around its edge, and is held in place by two damping springs, *D D*, each bearing on a small block of soft rubber, *a*, resting on the diaphragm at a point near its center. The object of these damping springs is to prevent too great an amplitude of vibration of the diaphragm, and also to keep it from vibrating in separate parts instead of as a unit.

Opposite the center of the diaphragm is the orifice, *E*, in the cover, *A′*, so hollowed out as to form a mouthpiece. The adjusting lever, *F*, is attached to the spring, *j*, secured to the lug, *B′*, of the ring, *B*. The lower end of this lever rests upon an adjusting screw, *G*, in the lug, *B²*, which is drilled and slotted as shown to prevent the screw from working loose. On the back of the diaphragm and at its center is placed the front electrode, consisting of a small bar, *e*, of platinum; one end of the bar rests against the diaphragm, while the other end is brought to a blunt point and is in contact with the

back electrode, *e'*. The electrode, *e*, is supported independently upon a light spring, *c*, mounted on the lever, *F*, but insulated from it. This spring tends to press away from the diaphragm and towards the back electrode. The back electrode is formed of a block of carbon, *e'*, set into a brass block, *g*, of considerable weight, mounted on a spring, *d*, supported on the adjusting lever, *F*. This spring, *d*, has a tension in the opposite direction to that of the spring, *c*, and being stronger than the latter it keeps the electrode, *e*, in contact with the diaphragm.

It is seen that instead of having one of the electrodes held in fixed position while the other is pressed against it with greater or less force by the vibration of the diaphragm with which it is connected, both electrodes are supported in such manner as to move freely with the diaphragm, but the outer electrode is so weighted that its inertia will offer enough resistance to the slight and rapid vibrations of the diaphragm to give a varying pressure between the electrodes and consequent changes of the resistance of the circuit. By this means the initial static pressure between the two electrodes will not be affected by changes of temperature, and the adjustment will therefore be more nearly permanent.

This transmitter is very delicate, but is lacking in power, especially when compared with instruments of later design. Besides this, it has a tendency to rattle or break contact, when acted on by loud noises.

Fig. 2 illustrates the Crossley transmitter, introduced into Europe early in 1879. This well illustrates the class very appropriately termed "multiple - electrode ". Transmitters devised by Johnson, Gower, Ader, d'Arsonval, Turnbull and many others are of this type, and differ merely in the arrangement and number of electrodes. They give much more powerful results than the transmitters having a single pair of electrodes, but most of them are subject to the grave defects of breaking the circuit entirely when subjected to loud noises.

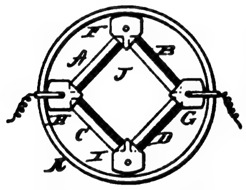


FIG. 2.—CROSSLEY TRANSMITTER.

In this figure *J* represents a diaphragm formed of a thin piece of pine board about ⅛ in. thick and mounted on a supporting ring, *K*. Fastened to this diaphragm are four carbon blocks, *F G H* and *I*, in the relative positions shown. These are hollowed out to receive the conical ends of the carbon pencils, *A B C* and *D*, which are supported loosely between them. The blocks, *H* and *G*, form the terminals of the transmitter. The current divides at the block *H*, and passes through the pencils, *A* aud *C*, in multiple to the blocks, *F* and *I*, and thence through the pencils, *B* and *D*, to the other electrode, *G*. Vibrations of the diaphragm cause variations in the intimacy of contact between the eight points of support of the four rods, and thus produce the desired fluctuations in resistance. It is seen that this is merely a modification of the Hughes microphone, the principles being the same, but the multiple contact allows a greater current to pass through the transmitter, and at the same time produce greater changes in this current than in the original form where a single pencil was used. Moreover, the liability of "rattling" is greatly reduced.

Fig. 3 shows the Turnbull transmitter which has been used to a considerable extent in this country, even until recently. In this figure *A* is the diaphragm of thin wood, on the back of which is mounted

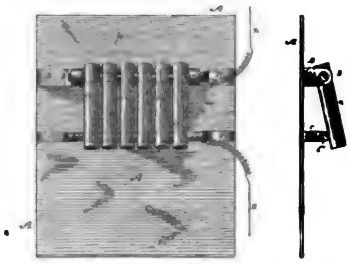


FIG. 3.—TURNBULL TRANSMITTER.

the bracket, *B*. Pivoted on a rod, *b*, carried by this bracket are several carbon rods or pendants, *a*, which rest at their lower end against a carbon rod, *c*, carried on a bracket, *C*, also mounted on the diaphragm. The rods, *b* and *C*, form the terminals of the transmitter and the current passes from one of them through the carbon pendants in multiple to the other. The variable resistance contact is mainly between the rod, *C*, and the pendants, *a*, although by making the rod, *b*, of carbon also an additional effect is obtained between it and the pendants. In most of the forms placed on the market, the diaphragm is rectangular and supported only at one edge. It can be seen that a very large amplitude of vibration is thus obtained.

Fig. 4 shows still another form of the multiple electrode transmitter, using carbon balls instead of pencils or pendants. *A* represents the vibratory diaphragm of carbon; *B* a plate of carbon having a number of cylindrical cavities, *t t*, upon one side. Fitting loosely in each cavity is a ball of carbon. The depth of the cavities is a little less than half the diameter of the balls, and the diaphragm is so placed in front of the plate that the balls following their tendency to roll out of the cavities will rest against its inner surface and also upon the edges of the cavities. Many other forms of instruments have been devised using one or more balls held in various positions between carbon plates. Some are used to-day, but all the transmitters so far described are being rapidly replaced by the Hunnings form of instrument, which, as has already been stated, uses carbon "dust" or granules for the variable resistance medium.

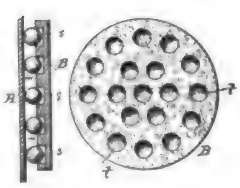


FIG. 4.—CLAMOND TRANSMITTER.

Tesla in Literature.

An English author who has written a successful novel entitled "Dr. N. Kola", recently stated in an interview that he got the name for the leading character from seeing in a paper while riding in a train, the name of "Nicola Tesla, the Italian Electrician".

THE STEAM ENGINE INDICATOR.

FAULTY POINTS AND LINES.

There are four events and five lines in the indicator card of a steam engine, and under given conditions there are certain positions which are best for each of these. A series of cards is given herewith, to show some of the incorrect positions and illustrate remarks on the remedies to be applied.

Great care and judgment must be exercised in criticizing an indicator card. It does not follow that if the card from a certain engine contains a fault, it is a poor card and requires correction. It may be that the attempt to do so wouid introduce new difficulties which are more objectionable. An engine room may be laid out in limited quarters and some of the apparatus may be arranged in exceedingly inconvenient positions knowingly, for the reason that nothing better can be done; still it is wise to examine these faults with a view to their correction in another and more favorable case, and thus it is with indicator cards.

On a Corliss or four-valve engine where all of the events of the stroke can be varied independently, any error in their position at any load is inexcusable. The lines of the card may be at fault for reasons beyond the control of the engineer, and the knowledge of how to interpret their meaning will be a guide for future experiences.

The cards here submitted have been constructed from actual cards, and care has been taken to emphasize the fault and suppress any other irregularities of the diagram. The idea is to give the reader a lasting impression of the appearance of the various incongruities that can occur.

The first card illustrates early admission and has the same mechanical effect as early compression. The admission line is made full the more clearly to emphasize the fault, as is indeed the case with the other cards. The objection to this is because the charge of steam is exposed to the cooling effect of the cylinder too long before it is used. It is desirable to have a moderately early admission for the reason that it is well to have the cylinder warm for the subsequent events of the stroke, but in the case shown it was overdone. The admission and steam lines join in a point like the beak of a bird, and this shows that full boiler pressure, or nearly so, was reached before the piston reached the end of the stroke. Preferably, the admission and steam lines should be straight and the " beak " effect shown is never desirable. So that this effect does not occur, the admission is measured by the slant of the admission line and may be good practice according to the conditions.

Late admission shown in Fig. 2 is also measured by the slant of the admission line, and so long as the little spire shown at the end of the card does not occur, is within the limits of good practice. Some part of the admission line should be at the extreme end of the card. Of course, great judgment must be used in determining the pitch of the admission line in either direction. The cards shown are absolutely faulty, but anything within these limits might be good practice according to the conditions.

Early cut-off is examplified in Fig. 3 and

is a common fault. When the cut-off is so early as to be actually wasteful, a loop is formed as shown. The area of this loop is to be subtracted from the area of the balance of the card and represents a positive loss in horse power. Often the loop is so large that the areas are exactly balanced and no horse power is produced by the charge of steam measured by the length and altitude of the steam line. Loops of any kind are to be avoided. In this case the remedy is to lengthen the cut-off or raise the steam pressure, but it could be far more intelligently applied when the card at the other end of the cylinder is consulted. It may be that the latter end of the cylinder is doing all the work, in which case a shortening of its cut-off will have the effect of causing the governor to lengthen the cut-off of both ends and thus eliminate the loop unless the governor is of the throttling type. In case both cards contain a loop, raise the steam pressure or increase the vacuum if a condenser be used.

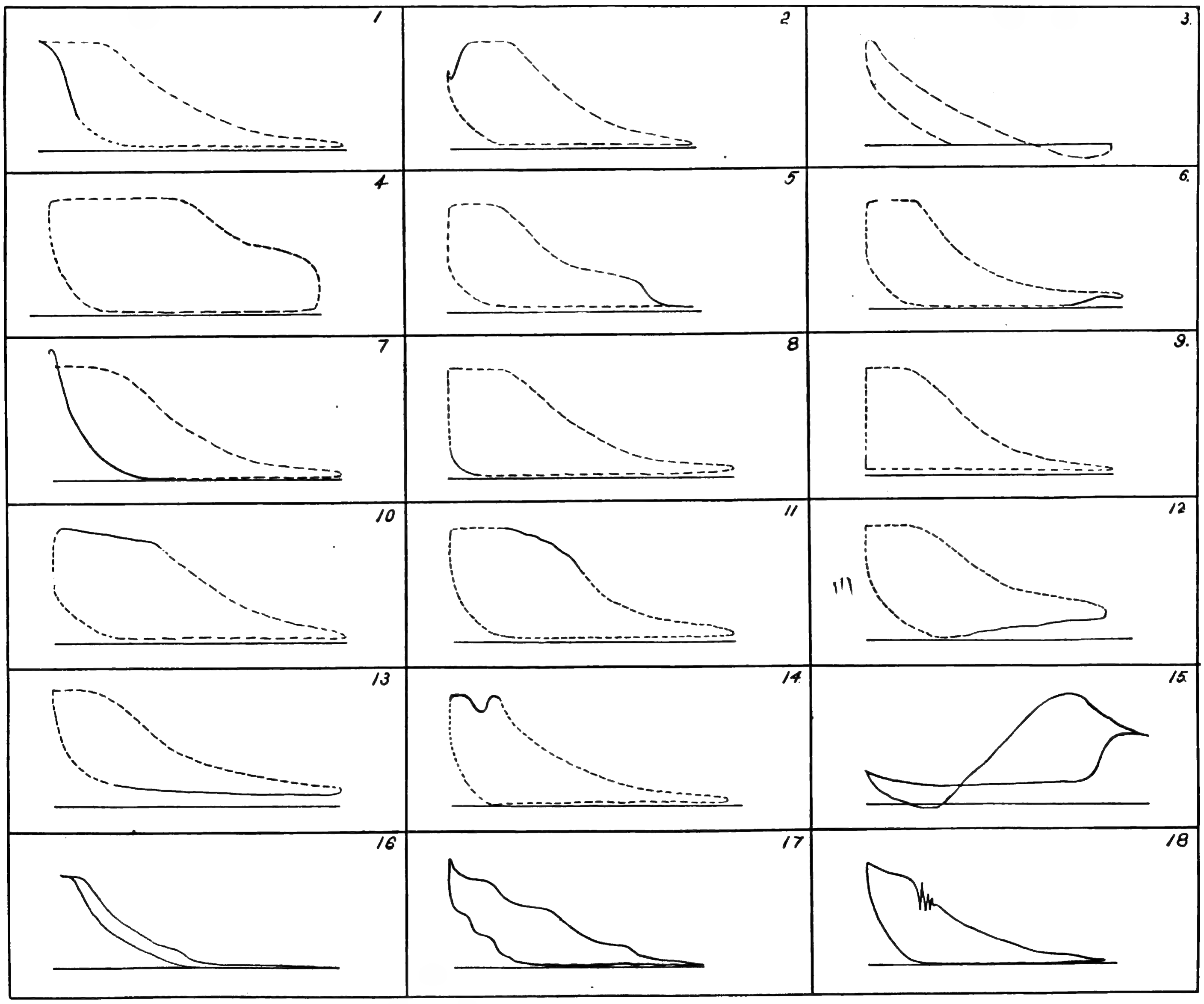
This card shows that a cylinderful of steam at a considerable pressure is thrown away when the release valve is opened. Its economy would be greatly improved by shortening the cut-off and raising the boiler pressure.

Fig. 5 is a case of too early a release and shows a positive loss of good steam, which is thrown away when it might profitably be retained and expanded still further. The available energy that is thus thrown away is measured by the area of the top of the normal diagram thus abruptly cut off. Late release, shown in Fig. 6, is not generally wasteful if the steam is expanded well down to the back pressure line, but release should take place preferably at the extreme end of the card.

the beginning of the steam line must be avoided. The slower the speed of the engine, the less the compression. Too little compression or none at all, shown in Figs. 8 and 9, must be avoided. Compression is one of the most flexible lines of the card. There are few compression lines that would not in some cases be very suitable.

The cases just discussed are more or less under the control of the engineer, and can be remedied by changing the valve adjustments or increasing the boiler pressure. This is not true of the remainder of the cards, which owe their faults to other causes.

Fig. 10 illustrates strangled admission and is due to too small ports, or to a defective valve mechanism which does not open the admission valve with sufficient promptness. Too small a supply pipe will also produce the same result, and such cards are often due to a throttle not being fully open.



SHOWING FAULTS IN INDICATOR CARDS.

Such loops as those just shown are of frequent occurrence on light loads, and if the load be normally heavy their elimination may act to the more serious detriment of the full load card. Such a card is shown in Fig. 4, which is also an example of late cut-off.

Early compression often introduces a loop into the card, as shown in Fig. 7. If it be accompanied by tardy admission, the loop will take the form of a spire. Compression compels the engine to seize a certain volume of steam and do work upon it by raising its temperature. The energy thus returned to the steam is of the most elusive form—heat—and is never fully given back to the shaft on the next stroke. Thus, while a certain amount of compression is advisable due to the greater smoothness of running, it must be judiciously used, and loops and spires at

Fig. 11 illustrates a leaky cut-off. This has the effect of changing the flexure of the expansion line. Normally this is inward, and if in any place it becomes convex, it may be ascribed to the admission of superfluous steam through some leak, always providing the indicator acts perfectly. In this case the cut-off valve did not get fully closed until the expansion line was fully under

LOCATION.	TROUBLE.	HOW INDICATED.	CAUSE.	TO PREVENT.
FIELD-COIL	Ground	Fuse blows out; Coil rings to earth	Excessive current	Repair its armature
			Insulation worn through	Tighten supporting spider
			Moisture	Open up drainage plugs, etc. Tighten commutator covers, etc. Use better waterproof insulation on coil
	Open-circuit	Car refuses to start on "series" notches. Can not ring through coil from terminal to terminal	Ground	Same as for ground as above
			Wire pulling out at connector	Sweat all cable ends. Use four screw connectors
	Short-circuit or burned out coil	Fuse blows out when running on "Multiple," notches; Unusual high speed of car; Unusual heating of motor	Excessive current	Repair its armature
			Bruise	Handle properly
			Fault in insulation covering of wire	Cannot be prevented by car repair men
ARMATURE	Ground	Fuse blows out; Commutator rings to earth	Excessive current	Repair field-coil; Handle controller properly
			Oil in head of commutator	Seal head up with mixture of plaster of Paris and shellac
			Lamination driven into armature coils	Renew armature bearings
			Faults	Greater care in winding
	Open-circuit	Insulation between two adjacent sections of commutator burned and eaten away. Long bright intermittent spark at brushes	Ground	Same as for ground as above
			Melting of solder at leads or at commutator connection	Better workmanship, using more solder carefully placed
	Short-circuit or cross	Flashing at brushes; Irregular and jerky action of armature	Bruise	Careful handling at all times
			Faulty connection	Correct and careful work
CONTROLLER	Ground	Fuse blows out; Flash and smoke inside of controller	Moisture	Keep cover closed and in good condition
			Dirt	Blow and wipe out dust once each two weeks
			Slow rupture of arc	Handle controller promptly, as directed
	Open-circuit	Car refuses to start, or starts, stops and starts again	Finger not touching contact drum	Inspection and adjustment of springs and contacts once each two weeks
			Loosened connection	Sweat cable ends, and screw up carefully
AUXILIARIES	Ground	Lightning arrester: Fuse blows out instantly finger (T) on controller rings to ground	Jaws of arrester touching	Set jaws properly
			Moisture and dirt between the jaws	Place arrester edgewise so that water and dirt cannot lodge in jaws. Place arrester in sheltered location
		Rheostat: Burning of woodwork. Shock to passengers when wood is wet	Broken insulators	Replace insulation
			Resistance strips out of place	Renew or repair strips
	Open-circuit	Lightning Arrester: Car refuses to start on any notch. Can not ring from fuse to (T.) on controller	Loosened connection at cables	Careful connection
		Rheostat: Car starts only on second, third or fourth notch	Damaged cell	Protect rheostat from moisture
			Loosened connection of cable	Careful connection
		Fuse-box: Car refuses to start on any notch. Can not ring from trolley-base to lightning arrester	Fuse blown out	Replace fuse
			Loosened connection of cables	Careful connection
		Cables: Car refuses to start, located only with magneto	Damaged insulation	Use nails and screws with care
			Fault at tap connection	Make all taps carefully, solder securely, tape and cover with P. & B. thoroughly
	Short-circuit	Rheostat: Car starts too suddenly	Bruised insulation	Handle carefully and place in protected location
			Oxidation of coils	Locate in position where water and mud will not be thrown upon it, or protect by covering in any convenient way
MOTORS	Noise	Pinion and gear not fitting	Pinion used in some other motor	Keep same pinion for motor when armature is changed
			New pinion or gear	Plenty of grease in gear casing. Cannot be wholly prevented.
		Loose gear	Bolts loose which hold halves of gear together	Tighten up bolts.
		Sprung armature shaft	Loose gear	Tighten up bolts of gear as soon as noise commences
			Piece of metal passing through gear	Replace any broken gear casing at once
		Bent car axle	Loose gear	Tighten up gear bolts as soon as noise commences
			Bad track	Prompt repairs of tracks
		Flat car wheel	Slip of wheels	Proper instruction and discipline of motormen. Lessen leverage of brake mechanism
			Natural wear	Use best brands of wheels
	Heating	Burned out field coil	Short circuit or ground	Replace or repair coil
		Armature rubbing against pole pieces	Worn out bearings	Renew bearings
		Brakes failing to release	Weak release springs	Tighten springs
			Brake staff not free to turn	Straighten and lubricate staff and its bearings

FAULTS OF RAILWAY MOTORS, THEIR DETECTION, CAUSE AND REMEDY.

way. In some cases the cut-off valve leaks continuously and yet the expansion line is not convexed. This may be detected by constructing a hyperbolic expansion line beside it and noting the divergence of the two, though condensation in many cases will falsify the showing.

Fig. 12 illustrates strangled release, which is generally due to some contracted area in the exhaust passages, possibly a partly open valve or an obstruction in the pipe, but more often a port that is too small.

Fig. 13 illustrates high back pressure, often resulting from the use of inferior feed-water heaters or an exhaust-steam heating system. A feed-water heater, if it be a proper one, should not sensibly increase the back pressure, but other devices for using exhaust steam might do so and the advantage gained therefrom be greater in comparison with the gain in having a line of lower pressure. In compound engines the position of the back pressure line with reference to the atmospheric line is of small importance as compared with its position with regard to the cards of the lower pressure cylinders.

Fig. 14 illustrates a most peculiar case of double admission. Steam was admitted and cut off very promptly, but the sudden drop of the dash-pot (it was a Corliss valve gear) was accompanied with a rebounding effect that was sufficient to overcome the difference of pressure that kept the valve on its seat and admit steam at nearly full boiler pressure a second time. It was corrected by confining this motion of the valve by a suitable plate.

Fig. 15 illustrates a card that results from giving the eccentrics a much reduced angular advance and delays all of the events of the stroke. Admission and cut-off, it will be noted, are reserved till the very last of the stroke. Some confusion may arise from the appearance of the card, which apparently begins at the right. Instead of that, it begins at the left, and reasoning on that assumption will quickly elucidate the mystery. The card may be corrected by increasing the lead of the eccentric.

Fig. 16 is a card in which all of the events take place too early, and may be corrected by reducing the angular advance of the eccentric.

Figs. 17 and 18 illustrate the difference between a vibrating and a sticky indicator mechanism. Wavy lines, such as both of them contain, may always be ascribed to the indicator, but in Fig. 17 the lines are unavoidable, while in 18 the reverse is the case. Fig. 17 is a high-speed engine card, and the inertia of the drum and pencil motion combined to produce the wavy registration, which will average pretty fairly in computing horse power or steam consumption; the undulations of Fig. 18, however, are due to the sticking of the indicator piston and introduce a serious error. The undulations themselves would probably average fairly well, but the pencil was making an incorrect registration during one of the most important events of the stroke namely, cut-off, and the diagram is, therefore, worthless.

Temperature of Vacuum Tubes.

Some recent experiments show that the rise of temperature in vacuum tubes is small, usually being less than 50 degs. F.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

FAULTS IN APPARATUS.

BY W. E. SHEPARD.

In the preceding articles we have considered some of the principal mechanical and electrical features of the several leading systems of electric railway motors. We will in this take up some of the more common of the electrical and mechanical *troubles* inherent in street railway motors regardless of the system.

These troubles may, for convenience, be divided into five classes, according as they appear in field-coils, armature, controller, wiring and auxiliary apparatus, or are of a mechanical nature.

In order to render as plain as possible the several most common faults met with in operating, electric motors are arranged in a more or less classified order, giving the location, nature of the trouble and the most usual and probable causes with manner of preventing repetition, so far as possible. (See p. 25.)

The details of the several systems not being identical render more explicit directions difficult to arrange without taking up each system separately, and for this space will not allow. Those given, however, are sufficiently definite to allow any workman, who may not be perfectly familiar with the various causes and effects of motor troubles, to proceed almost at once to the seat of the fault, and to remedy it without the uncertainty and delay with consequent guessing and experiment, so frequently necessary.

System in this work is always necessary—in hunting for faults as well as in the general making of repairs.

A thoroughly competent and keen inspector out on the road, whose duty it is to ride on each car at stated intervals, at least once a day; who shall report "bad order," and call attention to any cars which he may find irregular in any way, will pay for his necessary expense many times over.

The cars should be inspected regularly, ordinary repairs made on each car from time to time as unexpected faults occur, and each car sent to the "house" at stated intervals for thorough cleaning and overhauling of apparatus, taking the car off, though running in apparently good condition and before appearance of any trouble. In this way damage may be forestalled and expense of repairs kept at a minimum.

A system of this nature, supplemented by thorough and accurate work in the shops by competent and careful men, would place many a road on a better basis than otherwise would be the case.

Cost of Electricity in South America.

An English journal states that the cost of electricity at Buenos Ayres is 30 cents gold per kilowatt, a small discount being allowed to large users. It adds, however, that it must be borne in mind that all the coal used in generating this electricity has been brought some 7000 miles and that the wages paid both for labor and for technical knowledge is very considerably higher than in England.

LESSONS IN PRACTICAL ELECTRICITY

INDUCTANCE.

What will be the effect when the circuit of a coil carrying current is suddenly broken? To explain this we will start from first principles, though doing so will involve a repetition of some points previously treated. This, however, is not entirely a disadvantage, for the more directly any phenomenon can be connected with the principle upon which it depends, the better.

If a current flows in a circuit, such as that shown in Fig. 1, a certain definite num-

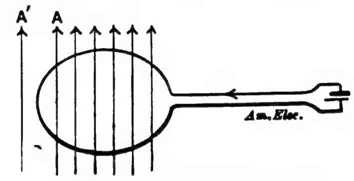


FIG. 1.—LINES OF FORCE OF SINGLE COIL.

ber of lines of force will exist in that circuit, the number being directly proportional to the value of the current for a plain coil without iron. If, now, the E. M. F. producing the flow is suppressed, as by short-circuiting out the cell shown, all of these lines must pass out before the wire becomes dead. In passing out, however (as from A to A), they will cut the sides of the circuit, and in doing so will generate an E. M. F. in exactly the same manner in which an E. M. F. is produced in the wires of an armature cutting the lines of force of a dynamo field. It will be seen that if the coil consists of a number of turns, the inductive E. M. F. will vary directly as such number, as one line in passing out will cut all of the turns. The property of a circuit just described is called its *self-inductance*, and the E. M. F. thereby produced is called an inductive E. M. F.

If a current could die out at a uniform rate from a circuit—that is, the same number of lines pass out in each interval of time—a voltmeter connected to the coil would show a steady E. M. F. until all of the lines had passed out. Now we know that if a wire moving in a field of force cuts 100,000,000 lines of force per second, a difference of potential of one volt will exist between the ends of the wire. Similarly, if we have a wire in a coil of, say, 1000 turns and containing 100,000 lines of force, when all of these lines pass out in one second, a difference of potential of one volt will exist between the ends of the coil, since 100,000 lines cutting 1000 turns are equivalent to 100,000,000 lines cutting one turn. Such a coil would be said to have an inductance of one *henry*.

Another way of considering the henry is to take the case of a current increasing or decreasing at the rate of one ampere per second. If a current varies at that rate and thereby produces an inductive E. M. F. of one volt at the terminals of the circuit, we know that 100,000,000 cuttings of lines per second are occurring to produce the volt.

The value of the inductance (L) of a circuit in henrys is, therefore, expressed by the number of volts measured at the terminals of the circuit, which are produced when a current passing through it increases or decreases at the rate of one ampere per second.

When a circuit carrying current is once electrically broken—that is, is no longer capable of conducting current—all of the lines it contained will have disappeared. Therefore, the more rapidly the circuit of a coil is broken, the higher will be the inductive E. M. F. at the terminals, since the more rapid will be the cutting of lines. It should be borne in mind, however, that the heated vapor from a spark will continue a circuit even after it is mechanically broken.

Suppose that the self-inductance of a coil is 10 henrys, which, as stated before, implies that if the current in it decreases at the rate of one ampere per second, the inductive E. M. F. will be 10 volts. Now if the coil is carrying 10 amperes and the circuit is broken in one second, the rate at which the current falls will be ten times as great as that of the definition, and therefore in a given time the cutting of lines will be ten times as rapid; consequently the inductive E. M. F. will be 10 (henrys) $\times$ 10 (amperes) = 100 volts. Now suppose that the time of rupture of the circuit is one-tenth second instead of one second; the rapidity with which the lines will leave the circuit is thus multiplied by 10, and the inductive E. M. F. will be increased to $100 \times 10 = 1000$ volts.

The inductive E. M. F. may thus be expressed by the formula, $E = \frac{L\ C}{T}$, where L is the inductance in henrys, C the current in amperes, and T the time in seconds. In the example just given, $L = 10$, $C = 10$, $T = \frac{1}{10}$; therefore, $E = \frac{10 \times 10}{\frac{1}{10}} = 1000$.

Let us take the case of an actual shunt dynamo (33 KW), having a total field of 11,000,000 lines of force and 3260 turns in the shunt coil. If all of the lines passed out in one second there would be $3260 \times 11{,}000{,}000$ cuttings, or if these lines were produced by 1 ampere flowing in the field, the inductance would be (since 1 volt is produced by 100,000,000 lines) 358.6 henrys; there were, however, 6.21 amperes flowing in the field, so that, on the definition basis of 1 ampere, the inductance is $358.6 + 6.21 = 57.7$ henrys.

Now suppose the shunt circuit of the above machine were ruptured in $\frac{1}{10}$ second; the inductive E. M. F. would be, from our formula, $\frac{57.7 \times 6.21}{\frac{1}{10}} = 3586$ volts. An ordinary 100-light machine may have an inductance of 10 henrys; if there are 2 amperes in the field and the current is broken in $\frac{1}{50}$ second, the inductive E. M. F. will be $10 \times 2 \div \frac{1}{50} = 1000$ volts.

In all that precedes, it has been assumed that the lines leave the circuit at a uniform rate. In point of fact, the lines leave fastest at the end of the period of rupture, so that the maximum values of the inductive E. M. F. are greater than those calculated, which are merely mean values.

A practical deduction from what precedes is that great care should be observed with respect to breaking circuits of high inductance. If a person should be in circuit when a shunt is broken, as, for example, having hold of a bare shunt wire on each side of a connector and pull an end out of the latter, though he would not break the circuit (his arms and body supplying a bridge), yet the lines passing out due to the decreased current would give a severe shock. In case, however, of an actually broken shunt circuit of a machine, the above principles apply directly. It can be imagined in the case of the large machine above mentioned, that the shunt might be broken in $\frac{1}{100}$ of a second, which would give a mean difference of potential at the terminals of over 30,000 volts, and a maximum difference much greater, which would undoubtedly result in breaking down the insulation.

If there is a switch on the shunt of a machine, it should, consequently, not be opened while voltage is on. In case of dynamos in parallel, it would be well to have the rheostat final contact short-circuit the shunt on itself. As arc machines have high self-inductance, a broken circuit is apt to puncture either the field or armature, since, unlike constant-potential machines, the armatures of arc machines have a high inductance.

There are several methods for preventing injury to an apparatus from the effects of its high self-inductance, two of which have just been mentioned. To provide against involuntary ruptures, a condenser may be

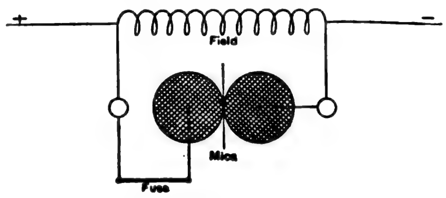


FIG. 2.—DYNAMO-FIELD SAFETY DEVICE.

kept in parallel with the inductance. This latter is also the method employed with induction coils to reduce the sparking attending the breaking of the primary circuit by the circuit breaker; unfortunately, one result is to weaken the coil, as the condenser draws off a part of the induction current that would otherwise be usefully employed. Fig. 2, shows a commercial dynamo field safety device. Here if the circuit is broken, the discharge due to the high induction voltage passes from one carbon disk to another by breaking through a thin strip of mica, instead of breaking down the field insulation.

It has been seen that the shorter the time of rupture of a circuit, the higher the inductive E. M. F. and it is evident that if this time could be made infinitesimally short the E. M. F. would be infinitely large. Advantage of this principle is taken in some cases to produce high voltages. For example, in the case of some circuit breakers used in generating Röntgen rays, an air blast is used to blow out the spark which occurs at break. As the vapor accompanying a spark, being conductive, prolongs the break, no break in air can be shortened indefinitely. As in a vacuum a conducting vapor from a spark cannot form, a vacuum break is extremely sharp. This latter fact has been utilized by Moore to obtain, by means of coils of extremely small inductance, inductive E. M. F.s sufficiently high at the maxima to light vacuum tubes.

Letters from Practical Men

Drilling Glass.

I have been experimenting drilling glass, and find I can make the holes in the glass plates of the Wimshurst machine, described in the November number of the AMERICAN ELECTRICIAN, with a brass tube, emery and turpentine, and an old-time fiddle drill bow, in fifteen minutes—a *perfect* hole, beautifully smooth on the sides. STATIC.

Insulation of Induction Coils.

I have made some experiments which would seem to indicate that a satisfactory insulator for static coils is yet to be found. None of the usual solids will do, for there must be no joints in the envelope surrounding the coils. Paraffine I find, while convenient, is only fairly satisfactory owing to the great difficulty of cooling it free from air bubbles. Air bubbles reduce the dielectric power of the medium at local points and inasmuch as the weakest point is the measure of one insulating sheet, it is obvious that air bubbles constitute a serious objection.

Oil I have found to be fully as unsatisfactory. It is true that it is continuous and free from air bubbles, but by convection currents set up in it discharge between two highly charged surfaces. Placing the terminals in oil and charging them to a high potential, I found the oil was thrown into commotion and a piece of light paper thrown on the surface thereof vibrated back and forth between the two terminals with surprising rapidity. When the terminals were removed, dripping with oil as they were, the drippings were projected from terminal to terminal in a fine stream, conclusively showing that they were carriers of discharge. What is needed in induction coil work is an insulator that can be melted and that will solidify into a dense homogeneous mass free from all faults that will reduce its dielectric strength. It should preferably be a material that does not shrink away from its mould.

DIELECTRIC.

Arc Troubles.

The writer once had charge of an arc light station run by water power. During one summer the water ran short and one of the circuits was transferred to a station run by steam. The machine had no automatic regulators, the regulation being done by hand by moving the rocker arm; it was belted to an engine that happened not to be in use and run at about 1000 r. p. m., giving eight amperes and feeding fifty lights.

Everything started up all right at lighting-up time (7.30 P. M.), with eight amperes showing on the meter. About nine o'clock the meter showed six amperes and no more could be gotten from the machine. The next day the governor springs were tightened on

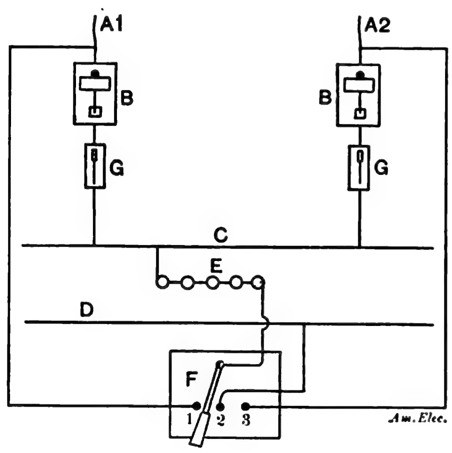
the engine which gave the machine 1400 r. p. m., and at night it started up with ten amperes, but again fell back to six.

This night occasional flashes at the commutator appeared, which showed that something was breaking the circuit. The circuit was thoroughly inspected by the lineman the next day and nothing was found. After starting up on the third night and waiting for the current to fall back, the superintendent went out with an inspector, and finding many lamps that burned blue the arcs of all of these were cut down until they gave a white light; after going over the circuit and finding a dozen or more lamps burning badly and regulating the same, it was found upon returning to the power house that the engineer could not hold the power down. The next day the governor springs were slackened, bringing the machine back to the original speed, and all trouble ceased. Perhaps some of those who read this have had the same trouble. H. S. HALL.

An Electric Railway Kink.

On most all the small street railways, whenever the circuit breaker comes out it is reset, without any knowledge as to whether the condition which produced the abnormal current still exists. Following is the way the writer arranged, at a small outlay, to test his line and thereby prevent the sudden jerk on the engine and dynamo. The arrangement is for a two-circuit board, but any number of circuits may be added by making a sufficient number of points on the switch.

A_1 and A_2 are feeders from the switchboard, *B B* circuit breakers, *C* trolley bus



bar, *D* ground bus bar, *E* five 50-CP lamps in series, *F* a three-point switch, and *G* feeder switches. If the circuit-breaker falls out on circuit, A_1, move the handle to point No. 1 on switch, *F*, and if there is any trouble on the line (such as a short circuit), the five lamps will light up, but if everything is clear, they will not light. When the lamps go out, set the circuit-breaker and put current on the line. The same explanation applies to circuit, A_2, and so on with as many circuits as there are. Point No. 2 on the switch is used at night to light the switchboard. When the lamps are lit in the cars, the lamps on the switchboard will show red when the line is clear, and bright when there is a short circuit.

S. L. BURGH.

Electrical Catechism

87. *Does the position of the brushes have anything to do with the successful balancing of the load?*

Very much. If the field coils and equalizer connections are adjusted for satisfactory division of the load, with the brushes of all the machines set exactly alike, it is found that shifting the brushes of any machine makes it take more or less than its share. The closer the brushes are to the neutral position, the more current the machine will deliver.

88. *Why does the position of the brushes affect the sensitiveness of dynamos?*

With nearly all dynamos it is necessary to move the brushes forward, that is, in the direction of rotation, when the load increases. This is because the current flowing in the armature coils exerts a magnetizing influence which distorts and weakens the magnetic field due to the field coils. On account of this distortion, it is necessary to move the brushes forward, so as to get them on or near the new neutral or non-sparking position. But the forward lead given to the brushes also increases the weakening magnetic effect of the armature current. It follows that if several similar machines are working in multiple, an equal increase of current in all the armatures would weaken the field of those having greater forward lead more than those with less lead of brushes. Consequently, the machine with more brush lead and weakened field would take a smaller proportion of the whole load than the one with little lead. (See No. 66, AMERICAN ELECTRICIAN, Vol. 8, p. 216, October, 1896.) In large stations it is important to give the same lead to the brushes of all the machines, so as not to throw all the load on a few in case of short-circuit or other sudden load.

89. *What is the trouble when one or two machines of a set refuse to take their share of the load?*

It may be too great resistance in the series field magnet coil or in the equalizer connections, so that the magnetic field is not properly strengthened as the load increases. (See Nos. 78, 84 and 86, AMERICAN ELECTRICIAN, November and December, 1896, Vol. 8, pp. 254 and 290). Too much lead of brushes has the same effect as just explained (see No. 88), or dirty commutator, loose or dirty connections in the brush holder or cables, loose connection between armature and commutator, will have the same effect by increasing the resistance of the armature circuit. (See No. 66.) Such trouble may also be caused by slipping of the belt, if too loose or if oily and slippery. This cause would be indicated when the dynamo takes its proper share of load until the load became heavy after which it would take less than its share or would take the same load regardless of the total load.

90. *What is an alternator?*

An alternator is an electrical generator that delivers an alternating current, as distinguished from a dynamo giving continuous or direct current.

91. *How is an alternating current different from a continuous or direct current?*

A continuous current is of uniform strength and it flows continuously in the same direction. An alternating current is continuously changing both its strength and direction. Alternating currents, such as used for lighting and power, follow more or less closely what is known as a sine curve. The current begins from zero value

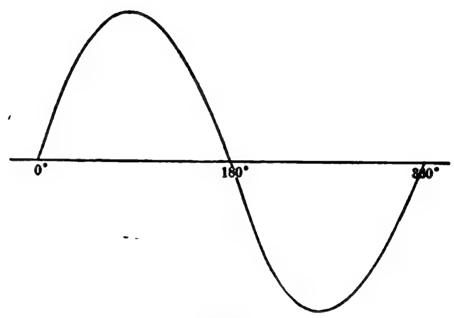


FIG. 1.

and increases rapidly to a maximum value and then decreases to zero, then increases in the other direction to a maximum value and again decreases to zero, somewhat as indicated in the figure in which horizontal distances represent time and vertical distances represent the varying values of current or electromotive force. This cycle is repeated from 25 to 130 or more times per second with the machines generally used for lighting and power.

92. *For what purposes are alternating currents used?*

For heat, light and power distribution, also for medical purposes. In fact, alternating currents are as suitable as continuous for almost any purpose except electro-plating and other chemical work. For arc lights the alternating current is not always as suitable as continuous current.

93. *Has the alternating current any advantages over continuous currents?*

Very heavy currents, such as used for welding, or currents at very high voltages such as used for long distance transmission, may be obtained more easily by alternating than by continuous currents.

94. *How are very heavy currents or very high voltages obtained?*

By means of transformers, sometimes called converters. A transformer consists of a laminated iron core more or less completely

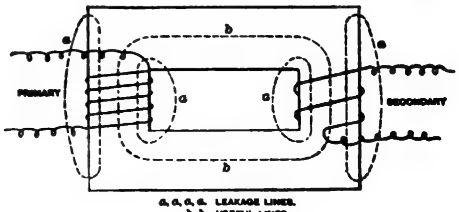


FIG. 2.

surrounded by two coils or sets of coils, one consisting of comparatively few turns of coarse wire, the other of many turns of fine wire as suggested by Fig. 2. If an alternating current of comparatively high voltage and low amperage passes through the fine wire coil, a current of low voltage and high amperage may be obtained from the other.

QUERIES AND ANSWERS

What book contains instructions for alternating current wiring? S.

"Davis Standard Tables for Electric Wiremen" has a section on that subject.

Why do motors of ½ to 2-HP hum when in motion? H. E.

Because of the high speed of rotation given the armature; the cause is not electrical, and the humming cannot be stopped.

How shall I wind an armature 3 ins. long and 4¼ ins. in diameter? A. J. B.

Full instructions for building and winding a machine of about this size will appear in a later issue.

Cannot the method given in section 72 of the Electrical Catechism for correcting a reversed dynamo be applied to a new generator that will not generate? A. B. W.

Yes. If current cannot be taken from mains, a few cells of closed-circuit battery will usually answer the same purpose.

How can I prevent a sulphuric acid cell from polarizing? W.

Nothing will prevent the polarization of a sulphuric-acid, single-liquid cell. Put the copper in a porous pot and surround with blue vitriol or, better, a solution of bichromate of potash.

Can the armature of a 500-volt street railway shunt generator be burnt out by a short circuit? F. W.

Yes, for the reason that the inductance of such a shunt field would be so great that the magnet would require an appreciable time to discharge, during part of which time an abnormal current would be generated in the armature.

1°. Is it advisable to run 5 arc lamps in series on a 220-volt circuit. 2°. What type of arc lamp is used ten in series on 500-volt circuit? M. C. B.

1°. With the usual arc adjustment 5 arc lamps will not burn well on a 220-volt circuit. A resistance is always necessary with arcs used on a constant-potential circuit. 2°. See the October number of the AMERICAN ELECTRICIAN.

An arc lamp of the clutch type works perfectly, except when the carbon is about one-third burned; it hangs up then and will not feed at all, but if the rod is pushed down a little by hand, the lamp goes on working properly until the carbon is all consumed. The rod is perfectly clean. What is the matter? W. S. P.

The rod is bent slightly and jams, or else there is a depression at one point which catches the clutch.

1°. How would the fields of a 1000-volt 2-phased alternator be connected up when the voltage is changed to 2000? 2°. Why are 2- and 3-phased currents best for long distance work? J. F. K.

1°. The exciter coils of the field would not be changed for any change whatever of voltage. 2°. Because of a saving in line copper and of permitting motors to be used on the receiving circuit.

Why does a Gramme-ring arc dynamo flash badly at times and run smoothly at other times? Magneto tests show no trouble in the armature or field or on the line. E. D. B.

There is either a "swinging ground" or a defective lamp on the circuit, or else there is a "remittent trouble" in the armature which comes and goes; the trouble is most likely on the line, however. Magneto tests are unreliable.

Having a transformer that was burnt out, I wound a primary coil and rebuilt it, the secondary coil being all right. It would then run a few lamps all right, but would not carry normal load without excessively heating. What is the cause? G. L. G.

The primary coil may, first, be wound with wire of too small a size, or second, not contain enough of turns. The second point would be clearly indicated if the secondary voltage were too high. The position of the turns would not affect the heating.

A standard street railway motor equipment gives trouble by running too fast and becoming destructively hot; I have changed the armatures and the field coils, but the motors behave just the same. What is wrong? L. M.

The data given are insufficient for an accurate diagnosis, but the trouble is probably due to wrong connections, whereby one or more field coils are connected in backwards. The mistake is probably at the junction block or at the controller.

How can I cut out a damaged coil on a four-pole railway motor having two brushes and an odd number of armature coils? L. M.

Take the terminals of the coil out of the commutator segments and connect by a stout piece of wire the two segments from which the ends of the coil were removed. Be careful to cut the ends of the coil pretty close up to the body of the armature and tape them thoroughly.

How can a single cell of storage battery be charged at the rate of 15 amperes from a 110-volt circuit? C. O. S.

By connecting in series with a resistance of about 7 ohms; or 15 32-CP incandescent lamps in parallel may be used instead of a wire resistance. This method is very wasteful, the resistance or lamps absorbing nearly all the energy used. Do not connect the cell direct to the circuit, as it would form practically a short circuit.

How can I change the cut-off of a throttling slide valve engine from three-quarters to half stroke without altering the valve itself? W. S N.

By reducing the throw of the eccentric and increasing its lead. The first operation will increase the lead and compression, and give an earlier release and cut-off; the second will readjust the lead and release. An article in a future number on the valve diagram will explain the principles of lap, lead and throw.

We have an 18-ampere, 2200-volt alternator run by water power, but can get up only enough speed to generate 1800 volts, a step-up transformer being used to bring the voltage up to 2200. Does this entail any considerable loss in efficiency? J. V. A.

As far as the machine itself is concerned, the efficiency may not be decreased as, though full advantage is not taken of the field, the armature iron losses are reduced. The machine and transformer together, however, entail a loss in efficiency, which may be considerable at light load.

1°. What size of wire is used in small induction coils? 2°. How are the connections made for using either the secondary or primary current? A. N. L.

1°. No. 36 in the secondary, and from No. 18 to No. 22 in the primary. 2°. Bring one end of the primary and one end of the secondary to a binding post, *A*; bring the other end of the secondary to a binding post, *B*, and the other end of the primary to a binding post, *C*. Then *A B* will give the secondary current and *A C* a shunted primary current.

Please give receipts for silver and nickel-plating baths. R. L. M.

For a silver-plating bath, dissolve 210 grains of nitrate of silver in one quart of water and add 350 grains of pure cyanide of potassium. Shake and filter. Add a few drops of ammonia (pure) to age. Use warm for small objects.

For a nickel-plating bath dissolve one part by weight of the double sulphate of nickel and ammonium, pure, in ten parts, by weight, of warm distilled water.

What causes the simultaneous flickering and clattering of all the arc lamps on a circuit? H. F. C.

This may be due to a defective lamp which fails to feed and opens the circuit by "hanging up," and then releases its carbon rod and re-establishes the circuit. It may also be due to the overloading of the dynamo, causing it to "let go" when a number of arcs are nearly at maximum length. Again, it could be caused by an imperfect dynamo regulator working without any dash-pot.

1°. What is the amperage of a Clark cell and how long will it last? 2°. How is a chloride of silver cell made? E. L. L.

1°. A Clark is not made to work on a closed circuit and would be rendered useless by so doing. 2°. In a large test tube containing salt water immerse a thin rod of zinc and a silver wire upon which melted chloride of silver has been made to adhere. The two electrodes pass through a paraffined cork sealing the tube. This cell is expensive and is only used for standardization or very special work.

Will the Wimshurst machine described in the November issue work a large Crookes tube? J. H. P.

A Wimshurst machine to work a large Crookes tube will have to be considerably larger than the one described. A machine with two 24-in. disks would answer fairly well. One with four disks would be better. On the high potential machines you will find it to your advantage to make the sectors about one-half the size of those on the machine described, of course allowing for the proper proportion if the size of the disk is increased.

What would be the difference of potential to which a person would be subjected if he should put himself in a ten arc-lamp railway series circuit; first, between the last lamp and the ground; second, between the feed wire and the ground direct? BRIG.

The potential would be practically the same on account of the high resistance of the human body. In the first instance the difference of potential would be as the resistance of the human body is to that of the armature, line, lamps and ground; in the second, the equivalent resistance of the lamps would be subtracted from the second term of the proportion. Assuming the resistance of the human body to be 2000 ohms, and the two other resistances 50 ohms and 1 ohm, respectively, the voltages experienced would be to each other as $\frac{2000}{2050}$ and $\frac{2000}{2001}$ respectively, of the armature voltage.

NEW Apparatus AND Appliances.

SOME NEW RÖNTGEN RAY OUTFITS.

Since there has been a demand for Röntgen ray apparatus, hundreds of devices have been produced and sold, but from the inherently experimental nature of such apparatus, satisfactory results were only obtained by experts and often the coils have been seriously damaged by ignorant handling.

Mr. E. V. Baillard, of 106 to 108 Liberty Street, New York, has worked upon the problem of producing durable, reliable apparatus of this class, and has succeeded in a marked degree. He has radically improved the induction coil and has actually succeeded in producing coils that average two inches of spark per pound of wire. For this reason the internal resistance of his coils is markedly lower than that of older types, and as a result the sparks that they deliver are thick and fat, or more scientifically said, highly calorific, and hence are particularly suited for Röntgen ray work. By means of improving the circuit breaker, he has succeeded in lengthening the sparks that the coil emits. The coils are highly finished in polished mahogany and vulcanite and present a very pleasing appearance. The coil condenser may be had adjustable or not, as specified. On larger coils the condensers are made adjustable on account of the greater range of resonance that this arrangement affords.

The coils are designed along lines similar to those outlined in the article by Mr. George T. Hanchett in another column, and many of the improvements therein mentioned are due to Mr. Baillard.

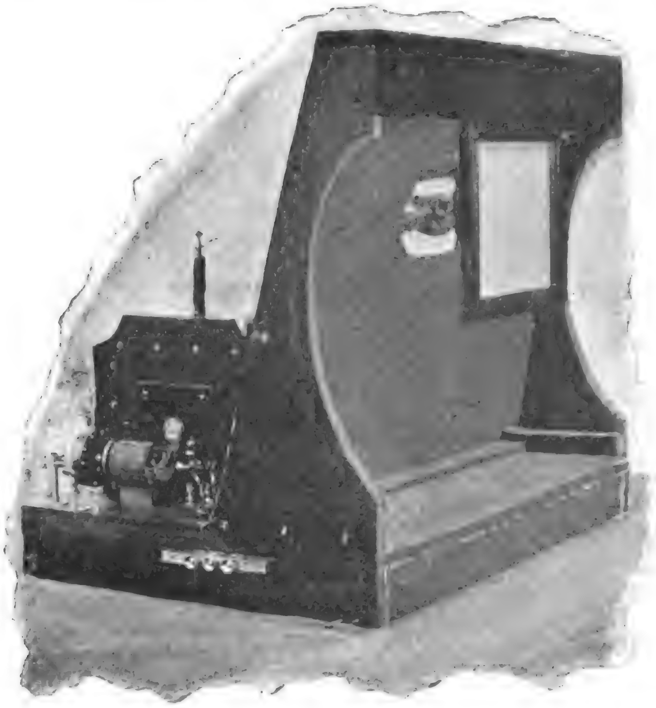


FIG. 1.—EXHIBITION OUTFIT.

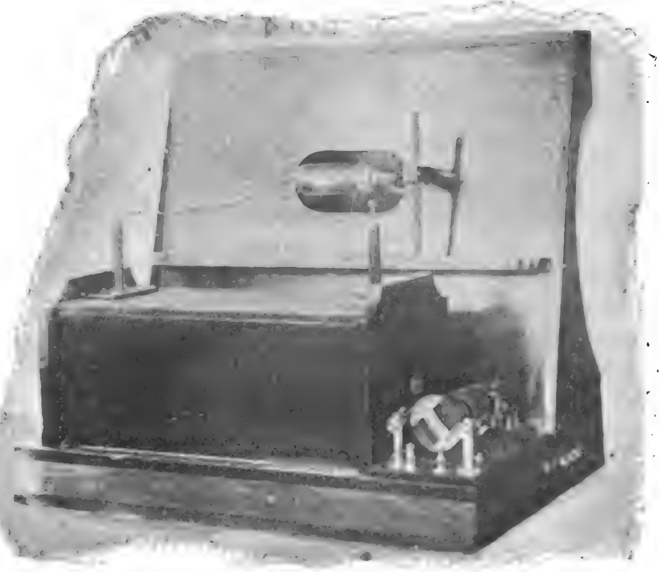


FIG. 2.—EXHIBITION OUTFIT.

Two principal types of Röntgen ray outfit are made. No. 1 is an exhibition outfit, two views of which are shown in Figs. 1 and 2. This comprises a large coil, a rotary circuit breaker driven by a small motor, and one or more tubes. Built on the baseboard of the coil is a hood carrying a large fluorescent screen which is suitably placed, that any reasonable object may be held between the latter and the Crookes tube. This screen is removable at will. The observer is cut off from contact with any of the coil terminals by a thin wooden shield, and therefore is in no danger of a shock. This apparatus is very popular where it is desirable to exhibit Röntgen ray phenomena to curiosity seekers where an admission fee is charged.

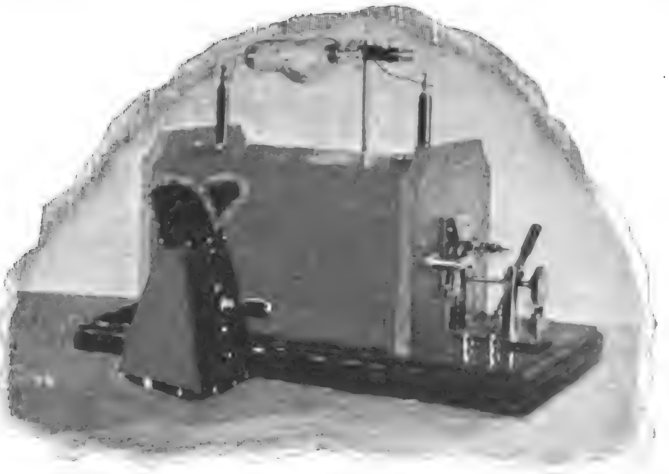


FIG. 3.—MEDICAL OUTFIT.

No. 2, shown in Fig. 3, is a medical outfit and comprises a coil, tube and fluoroscope. It is suitable for physicians and surgeons or experimenters, and permits of the examination of larger objects, such as the body or head of a man, and is an admirable apparatus where observation is to be conducted with more deliberation. It may be added, however, that with the aid of a fluoroscope the exhibition outfit may perform the same service. Mr. Baillard uses a tube of remarkable penetration, and by means of his apparatus examinations of the human trunk can be conducted with great facility.

Rotary vibrators and specially constructed coils are also made a specialty of, aside from a regular line of standard sizes. Mr. Baillard subjects all of his coils to the remarkably severe test of allowing either of the secondary terminals to spark on to the core. With most coils the spark thus obtained is thick and bright, indicating that there is a leakage between primary and secondary. With Mr. Baillard's coils, however, the spark thus obtained is thin and attenuated, showing conclusively that the core is a pole by induction in the same way that any external object presented to a secondary terminal would be, and that there is absolutely no commuuication between primary and secondary. This argues extreme durability and freedom from breaking down of insulation, a common difficulty.

AUTOMATIC RHEOSTATS.

The accompanying illustration shows a new type of rheostat with automatic release known as the "American," which contains several interesting features. The form shown is an automatic motor starter with a front for light current, and set at "full-off" position. The upper lever is the only one manually operated, and is used to cut out the resistance in the usual manner. The lower arm is the novel feature of the rheostat, and it is by means of this that the automatic release is accomplished, as follows: When the upper lever is moved to the "full-on" position, the lower arm is held in place by the small magnet shown, which is in series with the field of the motor, thus completing the circuit and allowing the current to pass through the box; when, however, either the field or the main current is interrupted, the magnet becomes de-energized and the lower arm flies away from the magnet. Should the current now be suddenly turned on again, it cannot pass through the

rheostat and injure the armature of the motor. When the upper lever is returned to the "full-off" position the lower arm is moved to its normal position by means of a simple interlocking device, and the motor can then be started up again.

Another form of "American" automatic motor starter has an attachment for protecting a motor against overload. The box performs the double function of motor starter and fuse block, and can be set in an instant for any degree of overload up to 50 per cent. of the rated capacity of the motor. The "American" automatic release is applied to speed-regulating rheostats in practically the same manner as to motor starters, thus accomplishing an important end by very simple means, and doing away with complicated catches or mechanism.

As the current is never broken on the upper lever of this type of rheostat, the wear and tear of arcing induced by such breaking is confined to the lower arm, and the slate and the contact points are thus saved from damage.

The above rheostats are made by the American Rheostat Company, Milwaukee, which also manufactures field rheostats of all sizes, either for front or rear of switch-

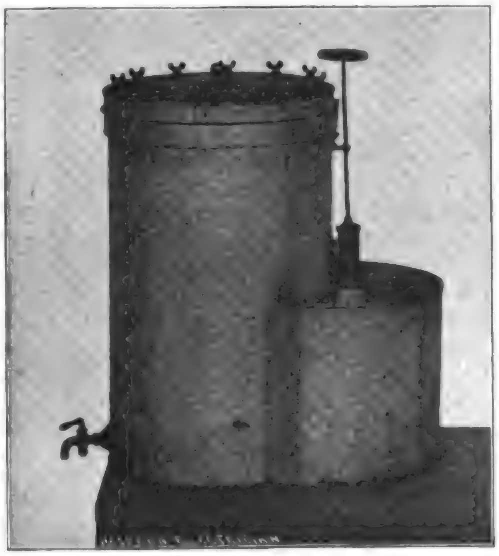
AUTOMATIC MOTOR STARTER.

boards, and resistance boxes for special work.

PNEUMATIC OIL FILTER.

The principle of the oil filter shown in the accompanying illustration lies in the use of pneumatic pressure whereby particles of metal are effectually removed from oil by forcing it under pressure through a diaphragm or other body of porous material, the material being permeable to the oil, but with pores of insufficient size to prevent the passage of particles of metal. The porous material employed for the filtering diaphragm may be ordinary blotting paper, which makes a very good filtering substance and can be had at a minimum cost. The filtering material should be continuous, so that all of the oil will be forced through the pores of the material, and should not be made up of material laid together in such a manner that the oil may trickle through the filtering material without passing through the pores. After the filtering operation has been continued for some time, the surface of the blotting paper, when examined under a microscope, displays a covering of finely-divided particles of metal which have been removed from the oil.

In one form of this apparatus, a receiving tank or vessel is provided, into which the oil to be filtered is poured; a perforated cover is provided for the tank, which prevents the entrance of foreign matter, such as waste and the like. A pump is provided to force the oil from the receiving tank into a pressure tank. The latter is air-tight with



PNEUMATIC OIL FILTER.

a pressure produced within by forcing into the tank a sufficient quantity of oil; if there be but a small quantity of oil in the receiving tank, air may be pumped into the pressure tank to provide the required pressure. A pipe extends from the pressure tank to a filtering receptacle in which is placed the filtering diaphragm. The oil is forced through the diaphragm under pressure and passes to an oil tank, from which it may be withdrawn for use as desired.

The pressure tank is cylindrical in shape, and placed within the oil tank, which is also cylindrical. The receiving tank, which is more or less of a crescent shape, is mounted upon the side of the oil tank, while the filtering receptacle containing the diaphragm is mounted upon the top, the pump being mounted upon the side of the tank with the handle in a convenient location, to be readily grasped and manipulated.

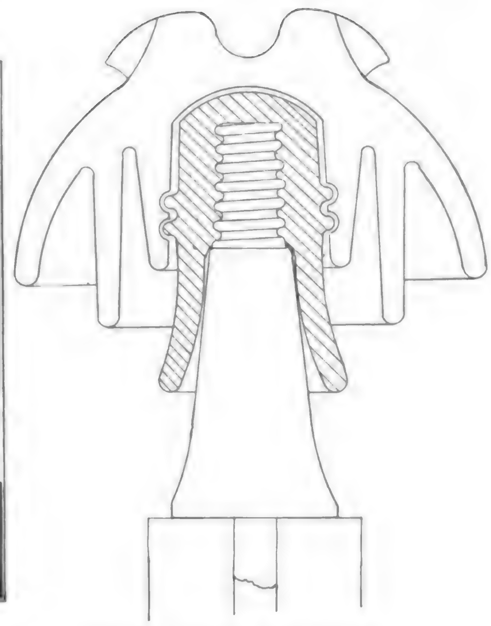
The tank above described is made by the Metropolitan Electric Company, 186 Fifth Avenue, Chicago.

HIGH VOLTAGE LINE INSULATOR.

High voltage electrical transmission has given rise to a demand for line insulation vastly superior to what had previously been found sufficient, and the insulator illustrated herewith has been designed to supply this requirement.

The insulator is made of porcelain, with a separate center insulating attachment of either glass or porcelain. The construction is both mechanically and electrically strong throughout, remarkably good results having been achieved in transmitting large currents for long distances at a pressure of 15,000 volts. At a recent test these insulators on the Locke steel pin carried 70,000 volts for four hours without heating, arcing or breaking down. This test showed conclusively that this combination of glass and porcelain offers a very high resistance to puncture and surface leakage.

These insulators have over 12 ins. of surface between the wire contact and the supporting pin. About 10 ins. of this surface is on the under side of the insulators out of



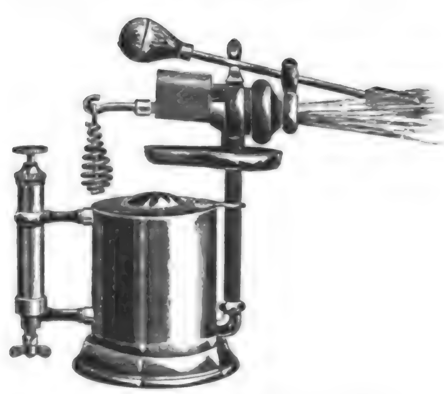
HIGH VOLTAGE INSULATOR.

reach of direct rainfall, where it keeps comparatively dry. The surfaces of the bottom of the insulators are perpendicular, and, therefore, catch no foreign matter. Locke's steel insulating pin, the top of which is made of locust wood boiled in paraffine, is designed to be used with these insulators.

The above described insulator is made by Fred. M. Locke, Victor, N. Y.

PETROLEUM COMBINED HOT-BLAST TORCH.

The hot-blast torch illustrated herewith is so designed and constructed as to vaporize kerosene oil or petroleum equally as well as gasoline. The heating power of the flame is claimed to be one-third greater than with the usual type, with a saving in fuel of at least one-half over gasoline. The tool is strong and well made, and can be used in-



HOT-BLAST PETROLEUM TORCH.

doors or out of doors in any position. As the torch uses petroleum, the wireman can, of course, obtain a supply of fuel anywhere. The torch is made by the White Manufacturing Company, 46 State Street, Chicago.

NEW STANDARD AIR COMPRESSOR.

One of the most difficult problems encountered in electric railway engineering has been that of braking. Owing to limitations of space, exposure to dust and dirt and the lack of high grade skill to be expected on the part of the average motorman, the design of an air-braking apparatus meeting these and other unfavorable conditions has called for prolonged study. The pioneer in this work, The Standard Air-Brake Company, has finally evolved an apparatus, the several essential parts of which are herewith illustrated, which is claimed to meet all of the various requirements.

As will be seen from Fig. 1, the air compressor is entirely independent of the car axle, being driven by an electric motor taking current from the trolley. If the trolley flies off there is always enough air remaining in the storage reservoirs to meet all demands. The 1-HP type occupies a space of 22 ins. long × 13 ins. wide × 17 ins. high, thus making it possible to put the complete outfit under a car seat. The motor, which is iron-clad and securely protected against dust and moisture, is of the slow-speed series multipolar type. The brushes are easily accessible for inspection and renewal, and the armature can be readily withdrawn by removing the front head of the motor. The motor frame is of steel and combines lightness with maximum capacity. The motor is insulated with extreme care to guard against possible grounding or breaking down

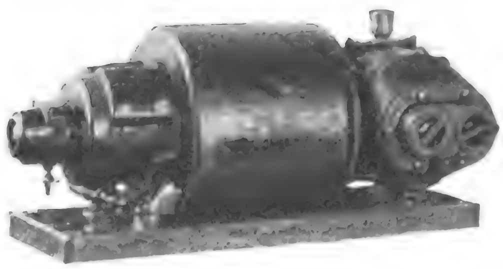


FIG. 1.—COMPRESSOR.

of the insulation. The armature is of the well known drum type with the sections made separately and bedded in slots in the face of core. Damaged sections can be renewed in case of injury, as in the case of car motor armatures. Special provision is made to prevent the ingress of oil from bearings and compressor.

The compressor is of the single acting type, with vertical double cylinders and trunk pistons connected directly to eccentrics in a crank case. The pistons are care-

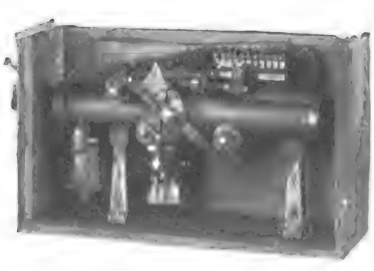


FIG. 2.—AUTOMATIC CONTROLLER.

fully balanced to insure freedom from vibration and noise. The eccentrics are lubricated by revolving in a closed chamber partly filled with oil, which is kept at such a height as to be always in contact with the sliding surfaces.

The compressor is bolted centrally with the motor, its shaft being a prolongation of the armature shaft, but not a part thereof. The bearings are phosphor bronze and may be readily renewed without dismantling the compressor.

The pistons are made air-tight in the cylinders by the use of two piston rings of cast iron, with overlapping joints. Any vibration of the compressor and motor is taken up by rubber cushions interposed between the motor-compressor and base, which latter is arranged in the form of a tray to catch any oil which may escape from the bearings. Oil cups which, with occasional filling, maintain a regular height of oil in the crank case, are suitably arranged.

The automatic controller maintains a practically uniform pressure in the air-storage reservoirs placed under cars or elsewhere. By its use, when the air supplied to the reservoirs reaches a predetermined limit, the motor compressor is entirely stopped. As long as the air pressure in the reservoirs remains within eight or ten pounds (or other adjustable limit) of the required maximum, the motor compressor remains

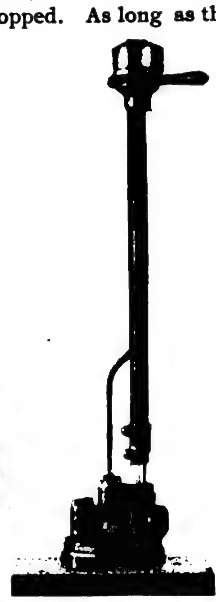


FIG. 3.—CONTROLLER HANDLE.

inoperative. Should the pressure, however, be reduced below the minimum limit, the motor compressor is immediately started, slowly at first, and gradually increasing as the resistance is automatically removed from the circuit, and continues operating until the maximum limit is reached, when it again immediately stops, as before.

The motor is series-wound and when starting with empty reservoirs, would naturally run away, but under such conditions, the resistance remains in the circuit and is only cut out as the pressure increases. The apparatus is equally applicable to a shunt-wound motor. The speed of the motor compressor is at all times automatically controlled by the amount of work required.

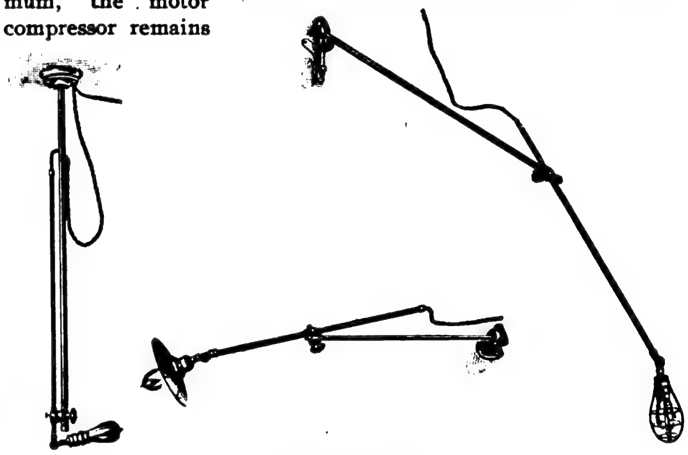
While the motor compressor is in operation, if for any reason the line circuit should be interrupted or the trolley leave the wire, resistance is thrown in circuit with the motor compressor simultaneously with the stopping of motor. When the current is again restored, the motor compressor resumes operation, gradually increasing speed in the way above indicated.

The type of automatic controller used is not only applicable to the control of the air brake compressor, but to various forms of motor and power control, such as in electric and other elevator practice, hydraulic and other pumping, handling cranes, bridges, etc. It may be used in all places where it is desirable to start or stop motors which, without its aid, would be well nigh inaccessible. For example, a freight or passenger elevator may be operated from any one of several landings by touching a button, once for starting and a second time for stopping. The controller occupies a space of 9 ins. × 10 ins. × 14 ins., and is furnished with lock and key, to be retained by the proper custodian, so tampering may be prevented.

This newest type of apparatus makes it possible for The Standard Air-Brake Company to equip any car, locomotive or train with its air-brakes. It is especially valuable on narrow gauge roads on which high speeds are maintained and where the car motors leave no room on axles for air compressors.

INCANDESCENT LAMP HOLDERS.

The convenience of a holder that will enable an incandescent lamp to be brought into any desired position and securely held there, is so evident that the value of the device illustrated herewith is at once evident.



LAMP HOLDER.

The holder is shown in three of the positions which it may be made to assume, and the ingenious system of joints admits of almost an infinite number of such adjustments. Owing to the range of the holder, lamps equipped with it may almost be considered portable.

The above adjustable holder is made by the O. C. White Company, Worcester, Mass.

NEW BALL VERTICAL ENGINE.

The engine illustrated herewith embodies in its design the result of a careful study of all the requirements implied in high speed and automatic regulation, and a wide experience in the construction of high class steam engines. The design is that of an engine whose structure is of such form that the main pieces are absolutely rigid and indestructible, yet allowing ease of access for the removal of any part that is subject to wear, and with a steam distribution equal on all sides of the pistons, whether one, two, three or four are used; in short, an independent valve motion for each cylinder employed, each of these being a perfect engine in itself.

The main feature as to strength and inde-

structibility is fully covered in the form of the upright housings, which are made to constitute one double housing by having one side of each planed and bolted together in the center of the middle shaft bearing. This substantiality is still further increased by planing the bottom of both housings to one continuous flat surface to meet the planed surfaces on the top of the single base plate to which the bottom of the housings is bolted.

The introduction of the shaft into this engine is accomplished by arranging the shaft boxes in a large jaw cutting into one side of the housing deep enough to bring the center of the shaft in a plane with the center of the housing, finished spots being provided to meet corresponding finished surfaces upon the cast iron boxes. These boxes consist of one bottom, two quarter and one top box for each journal, which are provided with removable babbitt metal shells upon which the journals bear. The shaft box jaws are in turn closed by the use of heavy struts, having on their inner faces a V-shaped tongue on each end, which fits into a corresponding groove planed on each side of the jaws. These struts are fitted so that when bolted in solidly the jaw is closed, and thus complete the symmetrical strength of the four corners of the housing, each strut being fitted so that there can be neither contraction nor extension of the outer end of the jaw.

THE BALL VERTICAL ENGINE.

Each housing is also pierced by a large rectangular opening on each side (shown covered by a door bolted on) as wide as the space between the inner edges of the struts, and extending both high and low enough to allow the cranks with their counterbalancing disks to pass. Hence, with shaft boxes and struts in place to close up the engine, it is only necessary to put up and secure the large doors, which in turn are provided with a small shutter plate covering an opening large enough for the insertion of one's hand to feel the connecting rod strap when the engine is in motion, or introduce the necessary wrenches to key up the crank boxes when so desired. The adjustment of the journal boxes is accomplished by turning the three set-screws shown in each strut, the two in the center reaching the quarter boxes, while the third one operates either in or out a wedge which fits between the lower side of the jaw in the housing and bottom of the lower box, thus giving independent adjustment for three parts of each box, while the lower box is perfectly free to move at right angles to the axis of the shaft; thereby giving for all positions of adjustment of the quarter boxes a full bearing for the shaft in the lower box.

Above the openings for the shaft the housing becomes a round taper column, having on two sides of the finished surface the crosshead guide surfaces, which are bored out coincident with the boring and facing of the upper end for the reception of the cylinders. The other two sides of each housing are pierced by elliptical openings giving easy access to the crosshead or upper end of the connecting rod.

It will be seen that in adopting this form of housing, a structure is obtained that is strong, convenient of access, clean as to any dirt leaving the engine, and entirely closed as to any dirt from the outside entering the engine, along with a natural ventilation past the shaft boxes, up the column, and out of the elliptical openings therein.

The shaft is one piece of forged steel from end to end. The crank pins are 180 degs. apart, cut out of the solid down to their round diameter, and, as well as the journals, ground to a perfectly smooth, round running surface. The pins are provided with centrifugal oil holes, the oil being delivered into a groove close to the journal and carried by centrifugal force out to the outer surface of the crank pin.

Covering each pair of crank bells is a pair of disks, carrying a sufficient amount of counter-weight to give a running balance to the crank and to the reciprocating parts, so that there is practically no vibration to be communicated to the housings, and hence to the upper works of the engines.

The connecting rods are of forged steel, the upper end being solid and cut out for the reception of a brass crosshead box and removable crosshead pin, the latter being tapered through the crosshead and held in place by a fine-threaded nut. The lower end of the connecting rod is provided with an excellent design of strap, which, owing to the arrangement of bolts and cross keys, constitutes a solid end rod for the crank as well as the best possible arrangement of wedge adjustment, and which in operation does not alter the length of the rod.

The crossheads are of a double-plate pocket type, as used in many makes of Cor liss engines. They are provided with taper shoes to compensate for any wear that may occur against the guides, the shoes being of cast iron; the running surfaces are spotted with babbitt metal, the area of which has been made liberal.

The cylinders are provided with single valves, each one of which is practically one piece, so far as motion or wear is concerned. The high pressure valve is of the double-face telescopic relief type, receiving the boiler pressure on the inside; there is a sufficient amount of unbalanced area on the faces so that the force of the steam on the inside forces the two faces apart, causing each to rub against the seat with a sufficient force to keep the surfaces polished and steam-tight through the entire life of the engine.

The low pressure valve is of the common letter D-type, but of an improved construction and proportion. It is provided with a round relief area upon its back, thus making a large, well-proportioned valve that runs with the greatest ease, yet follows up its wear without attention from the outside.

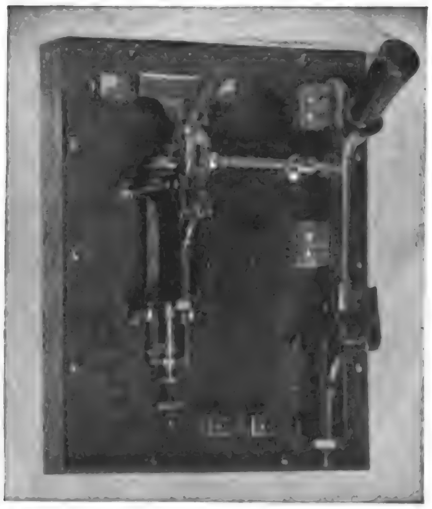
The type of engine described has been designed by the Ball Engine Company. Erie, Pa., and is now being manufactured at the works of that company.

Deterioration of Engine Shafts.

An English authority, Michael Longridge, says that it is now generally admitted that engine shafts break down from old age, and enumerates forty cases of shafts which seem to have failed from this cause.

ALTERNATING-CURRENT CIRCUIT BREAKER.

The circuit breaker shown in the accompanying illustration has been specially designed for use with alternating current machinery, and takes the place of the fuses which are so uncertain in action and accompanied with destructive arcing and permanent disfigurement of the switchboard. The appliance is specially designed to be placed directly in the dynamo in a position easy of access, and the absence of springs, weights and delicate adjustments makes it positive and certain in action. Though but recently placed on the market, this circuit breaker has had the test of long practice,



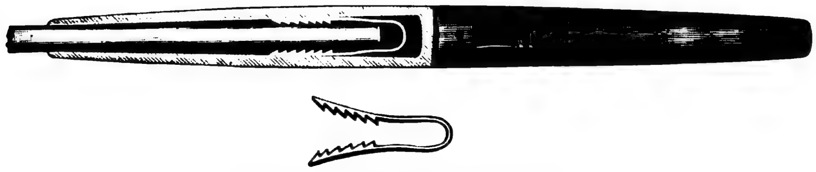
ALTERNATING CURRENT CIRCUIT BREAKER.

the Boston Electric Light Company having had its station equipped with them for more than two years. In a letter to the inventor, the superintendent states that during this time not a single armature has been lost from short circuits or lightning in any of the stations of this company since they were with the breakers, and adds that there seems to be no possible trouble on the dynamos or circuits that this device will not handle instantly, and that they form the best insurance that could possibly be placed on an alternating plant.

The circuit breaker described is now being introduced to the users of alternating current machinery by Leonard L. Elden, 305 Congress St., Boston, Mass.

AN AUTOMATIC WIRE CONNECTOR.

The "Monarch" automatic wire connector, shown in the accompanying illustration, enables a wire connection to be instantly made without the aid of a tool and, when necessary, at night without necessarily the use of a lantern. The connector can be taken down if



AUTOMATIC WIRE CONNECTOR.

desired without injuring the coupler and wire yet when in use it is impossible for the device which grips or holds the wire to fall out or become lost. The cut very clearly shows the principle of the connector, which is made by the Bradford Belting Company, Cincinnati, O.

ENCLOSED ALTERNATING-CURRENT ARC LAMP.

The enclosed arc lamp illustrated herewith is designed to fill the same place with respect to the alternating current that the

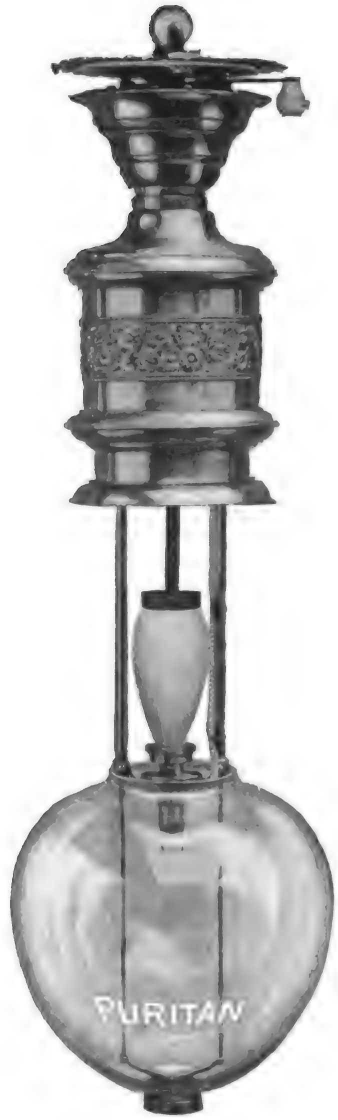


FIG. 1.—ALTERNATING-CURRENT ENCLOSED ARC LAMP—GLOBE LOWERED.

older form of the same type of lamp does with the direct current.

The mechanism is very simple and not at all liable to need repair or readjustment. The globe may be easily lowered and without any danger of breaking it. Two 7½ in. × ½ in. cored carbons are used, giving a steady and uniformly distributed light. The lamp can be used on circuits of from 7000 to 16,000 alternations, and voltages of from 100 to 120 volts. It is 33 ins. in length and of an artistic form, doing away with the chimney effect common in most lamps.

The same lamp by a slight adjustment of the resistance, will burn upon continuous-current, constant-potential circuits without change of mechanism, and is now being perfected for regular series arc circuits of 6.8 and 9.6 amperes, being thus universal in its application. One of the great features claimed for the lamp for alternating work is that it is noiseless, the importance of which

FIG. 2.—ALTERNATING-CURRENT, ENCLOSED ARC LAMP.

point is readily appreciated, and which should ensure its cordial reception.

The new type of lamp is made by the Puritan Electric Company, 150 Nassau Street, New York.

The Stevens Institute.

The 25th anniversary of the founding of the Stevens Institute of Technology at Hoboked, N. J., will be celebrated by a banquet at the Hotel Waldorf, New York, on the evening of Feb. 18, and the following day the Institute will be open for inspection, when the methods of instruction will be explained, and the apparatus of the various laboratories shown, to visitors. Stevens Institute was founded by the late Edwin A. Stevens, and in 1870 the erection of a building was commenced by the trustees. Dr. Henry Morton, at that time secretary of the Franklin Institute, of Philadelphia, was tendered the presidency of the Institute, and gathered a faculty of eight members about him. To this number others have from time to time been added, as the work of the Institute increased, until at the present time the faculty includes twenty-two professors and instructors. The total number of student graduates is 675, and the number in attendance during recent years has been about 260 each year.

PERSONAL.

Mr. H. Ward Leonard has been granted a patent, dated Dec. 2, 1896, on claims filed June 24, 1892, for his well known system of motor regulation. The patent includes no less than 62 claims on means for varying the E. M. F. upon, and current through, electrical translating devices, especially for the purpose of varying the speed and torque of electric motors.

Mr. Isaac M. Post, for the past eighteen years with The E. S. Greeley & Company and the L. G. Tillotson Company, has connected himself with the firm of Stanley & Patterson. Few men in the electrical trade have the extended knowledge of all of its details possessed by Mr. Post, and Messrs. Stanley & Patterson are to be congratulated upon having secured his services.

Mr. E. P. Thompson, joint author with Prof. W. A. Anthony, of "Röntgen Rays and Phenomena of the Anode and Cathode" has received a flattering commendation of the work from Lord Kelvin, as follows: "I received the book only a few days ago, but I have already looked nearly all through it, with great interest. I have seen enough to know that I shall find much most useful information in it which will be always available, because of the very excellent method and care with which you have given references to authors, dates, and publications, and I am sure that all who are interested in the subject will find your book exceedingly valuable. All your statements with reference to anything I have done on the subject are perfectly correct. I believe that hitherto nothing in the way of diffraction has been discovered for the Röntgen rays.

Col. Chas. B. Fairchild, formerly editor of the *Street Railway Journal* and one of the best known authorities in the world on everything pertaining to street railways, has connected himself with the Standard Air-Brake Company. Col. Fairchild was born in Berkshire, Mass., in 1842, and at the age of 19 years dropped his preparation for college to volunteer in response to President Lincoln's first call for troops, and served throughout the war, first for two years in the Twenty-Seventh Regiment, New York Infantry, and then in the First New York Veteran Cavalry as first lieutenant. During 1861-62, having been captured at the first Bull Run Battle, he spent 10½ months in Confederate prisons, being at Richmond, New Orleans, and Salisbury, N. C. In 1867 he entered the State Normal School at Brockport, N. Y., and was graduated from the classical department in 1870, and soon afterwards received the honorary degree of A. M. from Amherst College. After his graduation he was appointed professor in the Normal School, where he remained until ill health obliged him to resign. From 1880 to 1885 he was engaged in teaching in the public schools of New York City. The latter year he resigned and employed his time for nearly three years in the promotion of a cable railway system which he had invented. On July 9, 1889, he became associate editor of the *Street Railway Journal*, and the year following editor. Col. Fairchild is the author of two books, the "History of the 27th Regiment, New York Volunteers," a work of 335 octavo pages with illustrations, printed in 1888, and "Street Railways," issued in 1892 by the Street Railway Publishing Company. He resigned from the Street Railway Publishing Company June 1, 1895, and has since been engaged in developing an emergency pavement brake for street railways, the work having been carried on in Chicago and New York. This pavement brake will shortly be placed upon the market by the Standard Air-Brake Company, in connection with its system for braking cars and trains.

NEW BOOKS.

THE NATIONAL ELECTRICAL CODE. An Analysis and Explanation of the Underwriters' Electrical Code, Intelligible to Non-Experts. By Pierce & Richardson. Chicago: Charles A. Hewitt. 222 pages. Price, $2.

The authors of this book are electrical engineers of high standing and well fitted by practical experience in electrical work for the task which they assumed—to analyze the National Code section by section, and explain its matter in such simple language that no one can be at fault in regard to the meaning of its requirements. The result is a work which has, aside from its main object as a guide to electrical inspectors and electricians, the character of a practical treatise on the details of installation of electrical plants.

DIRECTORY OF THE STEAM AND ELECTRIC PLANTS IN NEW YORK AND BROOKLYN. 1896. New York: Manhattan Publishing Company. 204 pages. Price, $3.

The list of steam plants in this volume is complete for the cities of New York and Brooklyn, having been transcribed from municipal records. The list of electric plants numbers somewhat less than 500, but as it includes only those installed by four manufacturers, it is by no means complete. The directory will be of value to those to whom it is particularly addressed—manufacturers and dealers in steam machinery and appliances. The book is well gotten up mechanically and handsomely bound in flexible morocco covers.

ELECTRICAL MEASUREMENTS. A Laboratory Manual. By Prof. Henry S. Carhart and Prof. George W. Patterson. Boston: Allyn and Bacon. 344 pages, 142 illustrations. Price, $2.

Though primarily intended for the instruction of classes, this work answers many of the purposes of an industrial treatise on the subject of electrical measurements. The authors have not contented themselves with the mere description of a method, but have added an explanation or a demonstration of the principle involved, together with numerous references to original sources, thereby much extending the value of the work for practical reference. The section on the measurement of self-inductance is particularly full.

THE ELEMENTS OF ELECTRO-CHEMISTRY. By Max Le Blanc. Translated from the German by W. R. Whitney. London and New York: The Macmillan Company. 284 pages, 33 illustrations. Price, $1.50.

The growing importance of electro-chemistry from the commercial standpoint will cause this elementary treatise on that subject to be welcomed, as it is based upon the latest developments of the science. The first chapter establishes the fundamental principles of electricity, and the succeeding ones give an interesting account of the development of electro-chemistry up to date. Following are chapters on dissociation and the migration of ions, and the remainder of the book, with the exception of a very short final chapter on primary and secondary cells, is taken up by the subjects of conductivity of electrolytes, E. M. F. and polarization, the chapter on E. M. F. alone occupying considerably over one-third of the pages. The treatment of electrolytes and E. M. F. is very thorough, the latter including a very satisfactory account of electrolytic solution tension or pressure as developed by Nernst and Ostwald. The theory of voltaic cells is treated at length, and its application shown to the various types. We can unhesitatingly recommend this work as a valuable and timely treatise on a subject heretofore very inadequately represented in electrical literature, and a book that every electrician can read with interest and profit.

TRADE PUBLICATIONS.

Rheostats. The American Rheostat Company Milwaukee, Wis., in a neat pamphlet describes the several forms of automatic rheostats of its manufacture, which are clearly illustrated by well executed engravings.

Air Brakes. The Standard Air-Brake Company, New York, has issued a neat little pamphlet containing a large amount of interesting information relative to the Standard brake, including descriptions of the apparatus and cogent arguments in favor of its use.

Arc Lamps. The Puritan Electric Company, 150 Nassau Street, New York, has issued a handsome pamphlet illustrating and describing its new type of enclosed arc lamp for use on both alternating and continuous current circuits. The cuts enable the extreme simplicity of the lamp mechanism to be readily appreciated.

Walker Monographs. The two latest additions to to the series of technical monographs issued by the Walker Company, Cleveland, treat in detail of the distinctive features of Walker construction and of its manufacturing methods. Much information of a direct practical bearing not obtainable elsewhere appears in the pages of these pamphlets, which are issued from time to time.

Four-Pole Generators. The slow and moderate-speed belt-driven four-pole generators of the Colburn Electric Manufacturing Company, Fitchburg, Mass., furnish the subject of a pamphlet recently issued by that company. The slow-speed type is tabulated at from 850 to 525 r. p. m., and the moderate-speed from 1600 to 800 r. p. m., the capacities ranging from 6¼ to 62½ KW.

Graphite Productions. The Joseph Dixon Crucible Company, Jersey City, is a handsome pamphlet, bound in an illuminated cover, describes all of its various manufactures of graphite, which number a score or more, including lubricating graphite, graphite belt dressing, and a number of preparations for electrical purposes. Another pamphlet forms a technical treatise on silica graphite paint.

Steam Gauges and Fittings. The American Steam Gauge Company, 34 Chardon Street, Boston, has issued a-144 page octavo volume illustrating and describing its manufactures, consisting of steam gauges, indicators, safety valves, water gauges, etc. The book is a fine specimen of the printer's art, the page border being extremely effective. There is a gratifying absence of half-tone illustrations, wood cuts alone being employed.

Artistic Calendars. The handsomest trade calendar of the year that has come under our notice is one issued by the E. G. Benard Company, Troy, N. Y. The central ornament is a most enticing Pompeian female figure remarkably well printed in colored half-tone. The usefulness of the calendar is enhanced by the addition of a neat thermometer. Another striking calendar bears the imprint of the Cutter Electrical & Manufacturing Company of Philadelphia. An I-T-E automatic circuit breaker —full size—is embossed on the card, the several parts being gilded in imitation of the metals used. The effect is such as to create the impression that the actual circuit breaker itself is before the eyes. A calendar of the Eddy Manufacturing Company, Windsor, Conn., bears the imprint of a handsome Bartlett half-tone engraving of a direct-connected 120-KW generator, and one having the imprint of its New York agent, H. B. Coho, is illuminated by an engraving of an Eddy belted generator. The Puritan Electric Company very appropriately uses for the decoration of a calendar a reproduction of the familiar painting representing an armed party of Pilgrims proceeding to church on a winter morning.

BUSINESS NEWS.

J. P. Williams, 39 Cortlandt St., who recently returned from a very successful trip through the South and West, reports that his new fan motor, the "Paragon" is meeting with great favor among supply houses and users generally.

The Metropolitan Electric Company, Chicago, reports an increasing demand for medical batteries and supplies for experimental purposes, which is attributed to a growing interest in electro-therapeutics on the part of the medical fraternity.

The Electric Appliance Company, Chicago, reports that, notwithstanding the recent advance in price, the sales of Packard lamps have increased since that advance; the company considers this a high testimonial to the quality of the Packard lamp.

The Chicago Edison Company, of Chicago, reports a satisfactory business during the past year in its supply department. The outlook for 1897 is very encouraging and the company will push its specialties, including Hardtmuth cored carbons, Habirshaw and G. E. wires and cables, harder than ever.

The Baechtold & Parker Electric Company, 71 and 81 Washington Street, Brooklyn, has a new line of arc dynamos and lamps, and is in position to make complete installations. The company has a contract for installing a large plant in Brooklyn, using this apparatus, and the work of installation is well under way.

Chas. A. Schieren & Company, 45 Ferry Street, New York, received an order at noon on Dec. 30 for 118 ft. of 72-in., 3-ply leather belting for the People's Electric Light & Power Company, of Newark, whose plant was burned out on Dec. 29; at four o'clock in the afternoon of Dec. 31 the belt was in place, ready to run. This is said to be the quickest time on record, considering the size of the order.

The Ball & Wood Company, 15 Cortlandt St., New York, is receiving many encomiums concerning the great engine plant it installed in the electric light and railway power station of the Edison Electric Illuminating Company at Paterson, N. J. There are

nine engines in all and of the most modern type—the vertical marine compound condensing. Two of the engines are of 700 HP each, six of 600 HP each, and one of 315 HP.

The E. G. Bernard Company, Troy, N. Y., has received a letter from the Crescent Shipyard, Elizabeth, N. J., in which it is stated that the electric work on the ferryboat "Camden," done by the Bernard Company has given great satisfaction to the Pennsylvania Railroad officials and to the shipyard management. The letter concludes as follows: "It gives us great pleasure to compliment you upon this work, and to commend the thoroughness with which it was carried out by your Mr. Chasmer Devoe."

The O. C. White Company, of Worcester, Mass., is about to issue a new catalogue of its adjustable holders for incandescent lamps. Some three years ago this company began placing these much needed articles upon the market, and it now manufactures them in styles, sizes and finish adapted to every requirement. The introduction of these holders was attended at once with marked success and now many of the leading manufacturers of the country have equipped their establishments with them.

The Joseph Dixon Crucible Company, Jersey City, N. J., concludes a recent circular giving a review of the business situation of the year as follows: "Probably business men are not exceptions to Mr. Atkinson's favorite quotation from Emerson: 'Man is as lazy as he dares to be,' and we shall therefore shake off any lethargy that may have settled on us, and start in on 1897 at a record pace, for collections are now very good, and everything so far as we can see is encouraging to all manufacturers for both home and export trade."

Double Deck Street Cars. The double-decked vestibule street car being placed on the market by C. L. Pullman, of Chicago, is attracting much attention from street car managers all over the country, as the very latest and best application of progressive ideas in the improvement and comfort of cars for street service, as well as for the economy with which it can be run. The double-decked car is the first street car to employ a complete steel structure. The double entrances are on each side of the middle of the car, and four commodious stairways lead to the upper deck.

Leffel Turbines. The new power company at Niagara Falls has now in successful operation its new power plant, consisting of four of the Leffel Niagara type of turbines, each of about 2200 HP capacity. These turbines drive eight generators of something over 1000 HP each; two generators being direct connected to the shaft of each wheel, one at each end. This comprises, it is claimed, the most complete and perfect electric water power plant in the world. The same company has four other of the Leffel Niagara turbines, using in all eight of that style of wheel.

Mr. Jas. McLaughlin, 586 Fulton Street, Chicago the inventor and manufacturer of the well-known commutator compound which bears his name, is one of the practical pioneers in electric lighting and electric railways, having been superintendent of the Van Depoele Electric Manufacturing Company and an associate with the late Chas. J. Van Depoele in the construction of the first practical railway in America. The success of his compound is due to his knowledge derived from practical experience of what was wanted—a remedy for the ills that commutators are heir to.

The Gates Iron Works, Chicago, announces its advent in the high-speed engine business, with the Fischer-Gates single and four-valve, self-oiling, automatic engines, built according to the design and under the patents of Fred F. Fischer. These engines will be marketed by Fischer & Whiteside, at 700-702 Fischer Building, Chicago. Plans for extensive additions, to the already very large plant of the Gates Iron Works, are completed, and it is intended to push this branch of the business with the energy, experience and business tact characteristic of the company. A catalogue illustrating and describing the special features of the Fischer-Gates engine will be ready for distribution in a short time. The company has already booked quite a number of orders for Fischer engines.

The Chas. E. Gregory Company, 47 Jefferson St., Chicago, reports business rushing, with prospects for the current year most promising. Among recent shipments, besides many small motors and dynamos, have been the following: Arc machines: Wood, 60-light; three Sperry 20-light; Western Electric, 25-light; Brush, 45-light; Standard, 20-light. Motors: Thomson-Houston, 10, 20 and 25-HP; Sprague, 3, 10 and 20-HP; Jenney, 35 and 40-HP; C. & C., 50-HP. Incandescent dynamos: Edison, two 350-light, two 750-light, two 250-light, 200-light, 100-light and 12-KW; Westinghouse, two 360-light, 250-light; Western Electric, 600-light, 500-light; Mather, 1000-light, 150-light; Thomson-Houston, 500-light; Eickemeyer, 150-light; U. S. 200-light; Commercial, 30-KW; Royal, 50-KW; Westinghouse, 75-KW two-phased machine.

The American Engine Company, Bound Brook, N. J., shipped during the month of December, 1896, the following machinery: One 60-HP American-Ball engine to the *Scranton Truth*; one 50-HP motor and one 12-HP motor to the Western Newspaper Union; one 100-light dynamo to the Chattanooga *Daily News*; one 60-HP American-Ball engine to the *Albany Journal*; one 5-HP motor to the Gazette Publishing Company; one 12-HP motor to the *Toledo Blade*; one 12-HP motor to the W. D. Boyce Company; one 9-KW dynamo to the Age Herald Publishing Company; one 9-KW dynamo to the *Dayton Journal*; one 3-HP motor to the *Indianapolis Sun*; one 75-KW dynamo to the Philadelphia Inquirer Company; one 3-HP motor to the Harrisburg *Telegram*; one 9-KW dynamo to the Jarecki Manufacturing Company, and one 100-HP motor to the *Boston Herald*.

The Standard Air-Brake Company has begun the new year well, as the first order it received was from Germany, through its general representative, the Bergische Stahl-Industrie, of Berlin and Remscheid, for air-brake equipments for 30 double-truck motor cars for the Oberschlesische Dampfstrassenbahn. The company's motor-compressor type will be furnished, and in addition to the 30 outfits there is another order for 30 more to follow, making 60 cars in all. The significance of this order is apparent, as this road has been a steam road all along, but is about to be electrified. The company's foreign business is very active, and within the past few days requests have been received for some 300 additional equipments, for which it is expected contracts will be closed within a very short time. The company has not only increased its force, but has enlarged its facilities to meet the increased business.

The Electrical Exchange, Chicago, is now comfortably settled in its new quarters, where it occupies about 4000 sq. ft. of floor space. Of this the offices occupy 1000 sq. ft., the remainder of the store being divided into store room and repair shop. It is the intention to carry at all times a full line of electrical supplies and a good stock of electrical machinery. The repair shop is receiving particular attention, new machinery being added and a force of competent men secured. In June, of 1896, the entire stock of electrical supplies of the Jones Brothers Electric Company, Cincinnati, was purchased and in December of the same year the stock of the New York Electric Company, of Youngstown, O., consisted of something like 30,000 incandescent lamps. The Electrical Exchange was incorporated Nov. 1, 1896. The president of the company is C. L. Glasner, and the secretary and treasurer, T. S. Lane. The business at the present time is in a flourishing condition and the gentlemen in charge are to be congratulated upon the success which has, in such a short time, rewarded their efforts.

The Interior Conduit & Insulation Company, of New York, announces that it has placed upon the market a new and improved iron-armored insulating conduit, which is a development of its well known iron-armored conduit that has met with such success during the past few years. The results obtained with iron-armored conduit, while being much better than those given by the ordinary method of wiring, have nevertheless indicated certain points wherein the conduit could be improved so as to more efficiently fulfill its functions, and to attain this end the company worked persistently during the past few months. The result is the new conduit which is said to be much superior to any ever placed upon the market by the Interior Conduit & Insulation Company, in that it is extremely light, has a smaller outside diameter for a given internal diameter, and yet has greatly increased insulating properties. The insulating lining is of a flexible nature so that it is not impaired by bending. It is claimed that the new conduit will withstand a temperature of 175 degs F. without being softened, and that a ten-foot section will show an insulations of 11 megohms after being filled with water for ten days. This new product has met with prompt recognition by the trade at large.

The General Electric Company, has just closed a contract with the Third Avenue Railroad Company for the electrical equipment of its new extension from 165th Street and Amsterdam Avenue, New York, via the Kingsbridge Road to Spuyten Duyvil Creek, a distance of about 2½ miles. The power house will contain a battery of fifteen Babcock & Wilcox boilers having a total capacity of 2500 HP. The engines will be of the Allis-Corliss type from the shops of the E. P. Allis Company, and will be three in number of 1100, 700 and 500 HP capacity respectively. Each engine will be direct-connected to a General Electric multipolar railway generator, of 800-KW, 500-KW, and 300-KW capacity respectively. The switchboard will be of the standard General Electric panel type, and will be equipped with the latest switchboard apparatus. The overhead wires will be suspended from brackets set on ornamental central poles and each alternate pole will carry a 1200-CP arc lamp, current for which will be generated by two direct connected 125-light Brush dynamos. The feeders will be laid underground. The cars will be of the handsomest construction obtainable and will be set on double trucks. Each car will be equipped with two motors of the capacity of the G. E.-1000, one motor being hung on each inside axle. The first motor contract contemplates fifty double motor equipments.

The Ball Engine Company, Erie, Pa., reports that its vertical engines for electric service have been received with the greatest amount of favor by those who appreciate merit and good workmanship in an engine. Since Oct. 1 last, these works have been running till ten o'clock every night, and part of the time all night, on account of several large contracts received for vertical engines. Some of these orders are just being completed, among them being a 400-HP vertical cross compound engine for direct connection to a 225-KW Siemens-Halske generator, shipped a few days ago to the Nicopol Mariopol Mining & Metallurgical Company, Mariopol, Russia. The company will ship in a few days to the Chicago Public Library four 200-HP vertical cross compound, and one 100-HP vertical tandem compound engine, each to be direct-connected to two General Electric machines. The form of arrangement and the details of these engines are entirely new, it is said, and the plant when erected will be a very complete one. There are also under construction one 400-HP and one 150-HP vertical cross compound engines, for the Shoenberger Steel Company, Pittsburgh, Pa., each direct-connected to Siemens-Halske generators, and for the Apollo Iron & Steel Company, Apollo, Pa., one 150-HP vertical cross compound engine, direct-connected to a General Electric alternating-current machine, both the dynamo and exciter being driven from the shaft of the engine, and arranged on the same base with it.

American Electrician.

Vol. IX. New York, February, 1897. No. 2.

AN INTERESTING EXAMPLE OF PRACTICAL EXPEDIENTS.

On Dec. 29, 1896, the River station of the Newark (N. J.) Electric Light & Power Company was almost totally destroyed by fire, and the despatch with which the service was re-established and the many and ingenious practical expedients employed, furnish material for an interesting chapter on an unusual aspect of central station work.

After the fire was subdued, the condition of affairs was one of the most discouraging that could be imagined. Every dynamo was destroyed together with all of the electrical appliances, and the managers found themselves confronted with the problem of supplying 2400 arc lights and 14,000 incandescent lights with current. There was also a business of 300 HP in motors that was thus disabled. Every minute's delay was fatal to the interests of the company, and unless the service were re-established in a few days, the clamor for light would become intolerant. As it was, the current was on all circuits almost before the residents of Newark had recovered from the excitement of the fire and certainly before any complaint could be made.

While the fire was at its height it was seen that all of the dynamos would surely be lost whatever else the damage might be, and Mr. Philip N. Jackson, the president of the company, called the long distance telephone into play to order new ones to replace them. The Brush Electric Company, at Cleveland, was called up and an order for eighteen arc machines was placed at once. The works were closed on account of the moving of the business to Lynn, and Mr. Hamill, the general manager, was in Boston. Being notified by telephone, he ordered the works to be opened and the machines were taken from stock and shipped on a special train. The disaster occurred at five P. M., and on the second day at eleven o'clock the new machines were on hand. The Stanley Electric Company, of Pittsfield, Mass., received and executed with equal despatch an order for five two-phased generators. An order for the necessary belting was placed with the Jewell, Schieren and Bradford belting companies, and the work of reconstruction began.

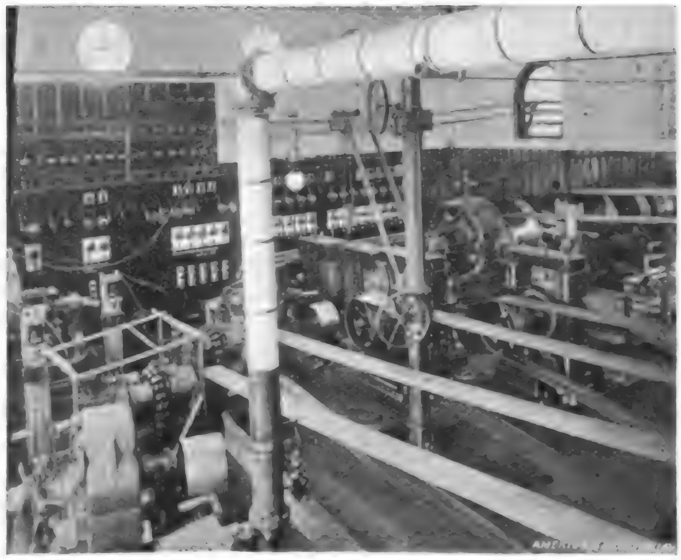
The first move was to look for available power elsewhere in order not to have a second night of darkness, for it was easy to see that to get machines turning over that

FIG. 1.—AN ENGINE THAT ESCAPED.
FIG. 2.—VIEW OF BURNED-OUT STATION.
FIG. 3.—VIEW OF BURNED-OUT STATION, SHOWING BRACING.
FIG. 4.—TEMPORARY BRACING AND WIRES.

VIEWS OF BURNED-OUT STATION.

evening at the burned-out station was hopeless.

The search for power resulted fortunately. Harrison, N. J., which depended on the Newark plant for light and power, was the easiest part of the problem. The Newark company had bought out the local lighting concern and closed down its plant, supplying instead the current from the river station. It was therefore a simple matter of starting up the Harrison plant again. The city lights of Newark, however,



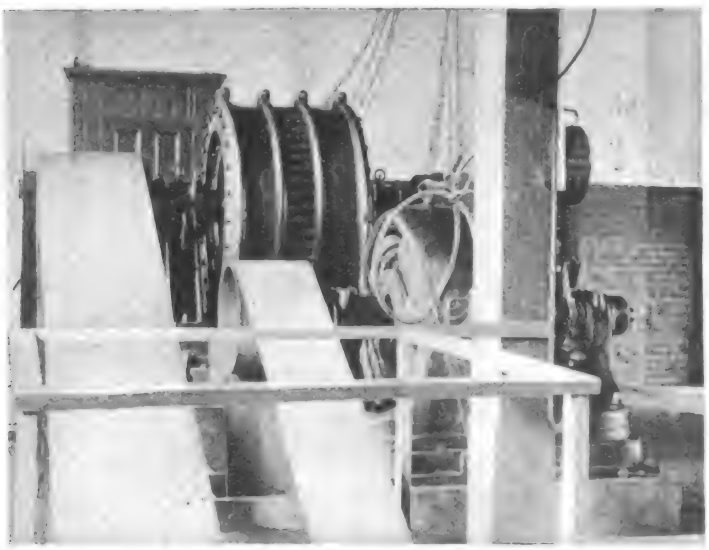


FIG. 5.—TEMPORARY INSTALLATION FOR ARC SERVICE.
FIG. 6.—TEMPORARY INSTALLATION AT MECHANIC STREET.

FIG. 7.—BOYD STREET TEMPORARY STATION.
FIG. 8.—TEMPORARY SWITCHBOARD, MECHANIC STREET.

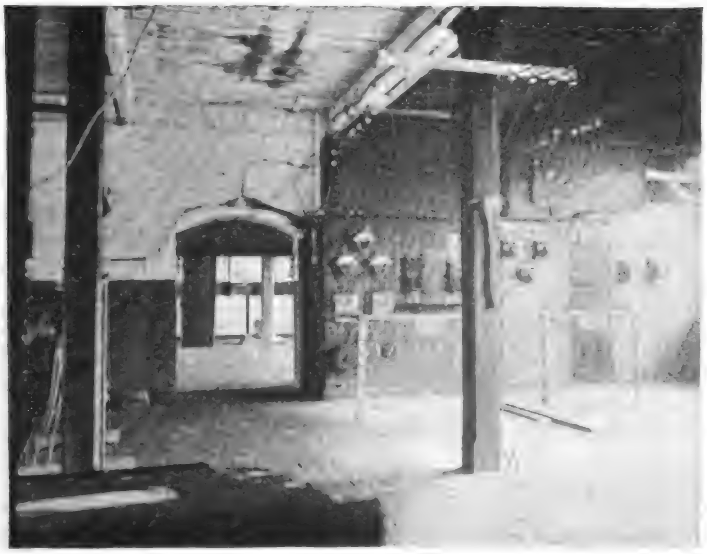
were important and pressing. It so happened that the Central Power Company, a small concern doing a 220-volt power business, had just been bought out by the Newark Lighting Company, and as there was power to spare at that station, it was at once pressed into service. The next evening after the fire there were two 125-light Brush machines installed there, and supplying the more important city lights. This was the first of the temporary plants to be started. Since that time the two Brush machines have been removed to do duty elsewhere, and there is now operating at that station a Wood 125-light arc machine (shown in Fig. 5). This machine, it will be noted, is run directly on the floor, but, of course, strong bracing from underneath was put in. No difficulty was found in running temporary mains; it was simply necessary to open the nearest point in the arc circuit to be supplied and tap in, short-circuiting the proper wires at the burned-out station.

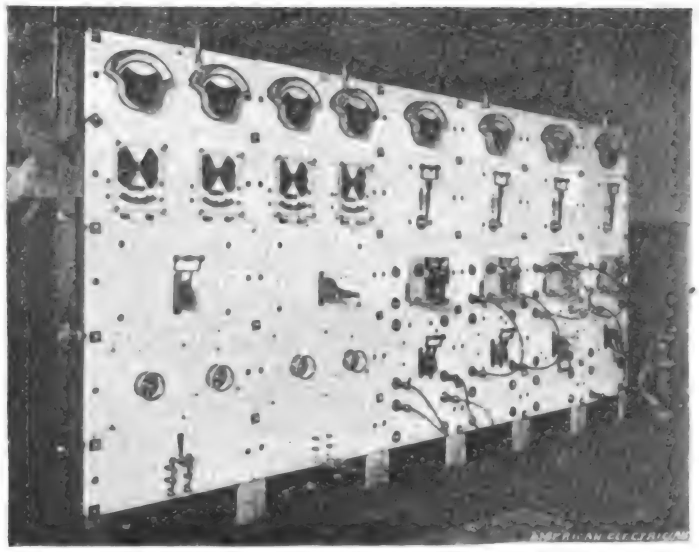
Another fortunate circumstance for the rapid re-establishment of service was the following: At Mechanic Street, Newark, there was a building that had been formerly occupied and was still owned by the Newark Electric Light & Power Company, and there were still there, in running order, 1000 HP in boilers and 800 HP in engines. It was simply a matter of installing machines there. Heavy joists were laid on the floor, and the latter was reinforced by stout props underneath, and three S. K. C. alternators were at once installed, two of 150-KW output and one 180-KW machine. From this station two trunk lines were run to a convenient distributing point. Figs. 6, 9 and 8 show how the machines were set up and some of the specimens of the temporary switchboard work. The wires were strung any way to get things started; windows were opened, and from a cross bar nailed to the casing, the wires that fed the points of distribution were supported. No time was taken to drill walls, insulator pins on the door casings supporting the wires through the doorways. Fig. 11 shows a board that was installed at this station which will become a permanent fixture. It is an S. K. C. board, made of white marble, and fitted with the customary instruments for the control and measurement of the output of a two-phase station. This board will ultimately be much extended.

The 110-volt power service demand was supplied by the installation of a small belted Westinghouse generator at this station. This machine is shown in Fig. 6. In justice to the Stanley-Kelly alternator shown in the same picture, it should be said that the direct current machine near by, while it excites the fields of the alternator, has other work of greater magnitude to do, and the alternator excitation is but a small portion of its duty. This explanation is thought necessary as there are alternating sets that might be suggested by the ratio between alternator and exciter shown in the picture.

These temporary stations by no means filled the demand in the various systems they supplied, and it was resolved to rent power of the Consolidated Traction Company. Arrangements were made whereby the Boyd Street station was placed at the

disposal of the lighting company. The railway generators were shoved to one side and the arc machines put in their places. Fig. 7 gives a very good idea of the rapid work done in this quarter. Two 125-light Wood machines and two 100-light Brush machines were installed here. At this station there was power to spare and it was the original intention of the Newark Electric Light & Power Company to install much more machinery here, when it was discovered that the engines could still be used, although the heat had been so great as to burn the lagging off the cylinders and the covering off the steam pipes. One of the cylinder castings was cracked, but it was ingeniously patched so as to be rendered serviceable. An idea of the condition of the cylinders can be obtained from Fig. 1. An immense crane which swept the entire station was very near these engines. The heat was so great that this crane was warped at least





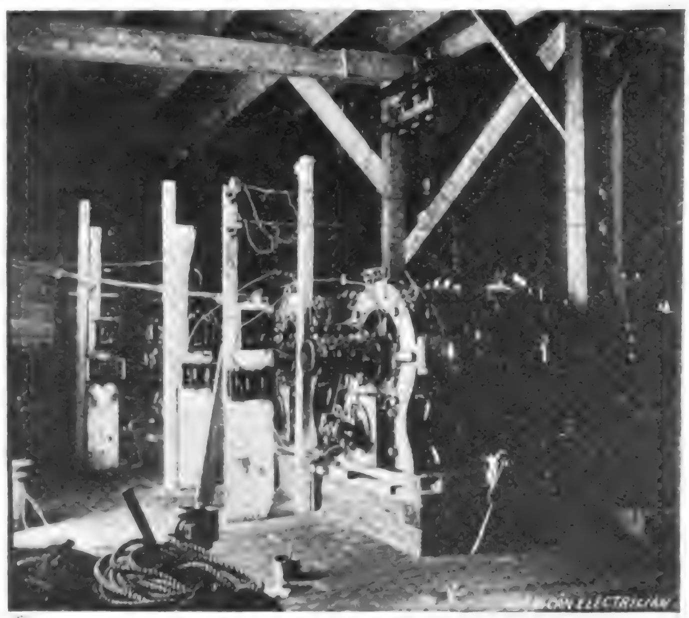


FIG. 9.—TEMPORARY SWITCHBOARD, MECHANIC STREET.
FIG. 10.—ALTERNATING INSTALLATION AT BURNED-OUT STATION.

FIG. 11.—NEW SWITCHBOARD AT MECHANIC STREET STATION.
FIG. 12.—ARC INSTALLATION AT BURNED-OUT STATION.

eight inches out of true, and how the engines endured is a mystery.

The boiler room had almost entirely escaped. One boiler whose steam had blown itself off, had a few tubes burned out, but that was the extent of the damage in this department. The engine and dynamo room was divided into two parts by a brick wall, and one half was so thoroughly burned that absolutely nothing contained therein was usable. Unfortunately, this part contained the switchboard, and seventy-nine circuits were thus disabled. The wires had to be brought to the temporary station that was in process of erection in the less disabled part of the station, or fed from elsewhere as the judgment of the engineers might dictate.

Figs. 2 and 3 show this completely-burned half of the station, the views being taken from opposite ends. In Fig. 2 the remains of the balcony switchboard may be seen dangling from the wall. The holes that were formerly outlets for the circuits can also be seen. In this picture the debris from the falling roof had been cleared away, and the former arrangement of the station can be seen and will be recognized by those familiar with it.

The other part of the station over which the roof and walls still remained contained an arc plant. The foundations of the dynamos were found to be only slightly charred and would still support a machine. Holes were torn in the walls and the ruined dynamos were thrust through them out into the yard. In Fig. 4 they may be seen lying in the snow. The heavy crane was examined and found to be dangerous as well as useless, and it, too, was taken down and thrust out into the yard.

A gang of carpenters was set to work to repair the roof and walls. The latter were

the two engines at the burned-out station were usable. The Consolidated station was borrowed power, and therefore any chance to use the means already possessed was not to be missed. Moreover, the installation of anything other than arc service at these temporary stations entailed the construction of trunk lines to the distributing centers and that expedient was both expensive and slow.

It was at once resolved to rebuild enough of the river station to utilize the power of the two engines, and a most creditable piece of engineering was the result. A rapid inspection of the ruins, while they were still smoking, had revealed the fact that two of

found to be unsafe and bracing was necessary. This was accomplished by a system of diagonal struts that were placed at intervals along the walls. In Figs. 3 and 4 these braces may be seen. The ruined machines performed a last service by acting as heavy weights against which these stays could be placed. The stays, as will be noted in Fig. 4, served as convenient supports for the temporary wiring which issued from every window. The roof was found to be so leaky as to afford inadequate protection to the dynamos, and a new roof was constructed under the old shell. It was quite substantially made and strongly braced, as will be seen in Fig. 1, and it will serve to support the heavy material used in constructing the permanent roof and in dismantling the old one. The multitude of pillars and cross stays was a most convenient circumstance for the temporary wiring system, and the wires they carry spread in every direction among them like a veritable spider's web.

The charred foundations of the ejected machines were reinforced by rectangular frames of two-inch planking, and the new machines were placed in position thereon. The cases that contained the machines were knocked apart and made into rude supports for the instruments and wall controllers, and after the belts were put on and the wires connected, the station was ready for business. Thirteen arc machines and two alternators were installed here, and views of the alternating and arc departments are shown in Figs. 12 and 14.

The alternating circuits were absolutely unprotected till, in response to a telegraphic order, the Cutter Electrical & Manufacturing Company, of Philadelphia, supplied them with eight alternate-current circuit breakers. These instruments were not in stock, but by making special efforts they were delivered and metalled within sixteen hours after the receipt of the order. They were of the I. T. E. type and have proved very satisfactory. It remains to be said that the plants thus hastily installed have done splendid service, and that no trouble from short-circuits or grounds has yet been experienced. There was but one night of absolute darkness. The next night there were 250 arc lights. On the next 480 KW in incandescent service was added, and before a week had elapsed the entire service had been re-established. The feat is a record in the annals of electric lighting, and was not accomplished without great labor, which continued both night and day without intermission. Meals were served in the grounds and every man that could profitably be employed in one capacity or another—the matter of expenses necessarily having to be considered of secondary importance—was set at work.

Great credit is due to the tireless efforts of Mr. Peter Wright, general superintendent, and Mr. John J. Gaffney, superintendent, the latter being in immediate charge of the burned-out station. But even the splendid efforts of these gentlemen would have been vain had it not been for the magnificent response of the companies to the orders of Mr. Jackson. His discretion in making orders and securing the co-operation of the railroads in their prompt delivery, were the prime factors in restoring service.

ROTARY CONVERTERS.

BY ERNST JULIUS BERG.

Within the last few years a number of articles have been published giving a more or less complete description of the action of induction and synchronous motors, their advantages and disadvantages as compared with continuous current motors and their reactions on the system on which they are operating.

The action of rotary converters, however, and the conditions under which their use is desirable have, to the writer's knowledge, hardly been touched upon, and still less the reaction of these machines on the alternat-

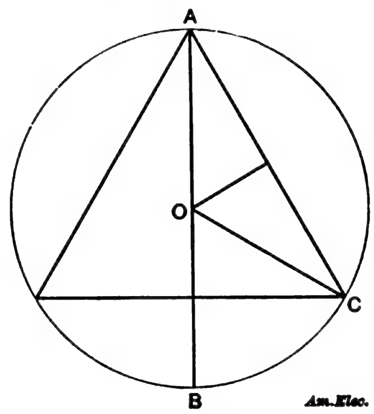


FIG. I.—RELATION BETWEEN CONTINUOUS, ALTERNATING, AND THREE-PHASED VOLTAGES.

ing system, their methods of operation, and the limitations imposed by their use.

The commercial considerations of, for instance, the maximum distance at which the continuous-current system may be cheaper than the converter system, etc., will not be discussed, since they are easily handled by any electrician. It may suffice to say that the amount of copper in the high potential line will be the same for simple alternating and two-phased distribution; the amount is somewhat less in the three-phased system than at the same voltage with the continuous current, the copper in a three-phased distribution with non-inductive load being 75 per cent. of that of a continuous-current system with same effective voltage between lines.

Obviously the voltage used in the alternating transmission lines would be so high that continuous currents could not be transmitted nor used at this voltage, and the comparison with continuous current is thus only for the purpose of giving a simple means of calculating the amount of line copper.

The Rotary Converter.—A rotary converter is essentially a continuous current generator supplied with two or more collector rings connected to suitable points of the continuous current winding.

It does not transform E. M. Fs. and currents as a stationary transformer, but merely converts alternating into continuous currents, and each type of converter has its definite ratio between alternating and direct-current voltage.

Assuming a sine wave of E. M. F., the effective impressed E. M. F. of a single or two-phased rotary converter is $\frac{1}{\sqrt{2}}$ or .707 that of the corresponding continuous current. In a three-phased converter the alternating voltage is $\frac{\sqrt{3}}{2\sqrt{2}}$ or .613 of the continuous current E. M. F.

Fig. 1 shows how these values are obtained. If E, is the continuous current E. M. F., then $A\,B$, representing the corresponding alternating voltage, is $\frac{E}{\sqrt{2}} = .71$. Thus $A\,O = \frac{E}{2\sqrt{2}}$ and $A\,C$ = three-phased voltage $= \frac{\sqrt{3}E}{2\sqrt{2}} = .613$

If rotary converters are operated from a high-potential line, step-down transformers

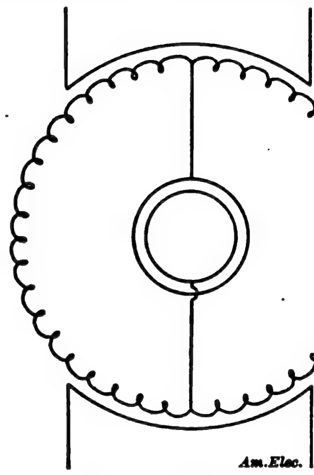


FIG. 2.—TWO-POLE SIMPLE ALTERNATING-CURRENT ROTARY CONVERTER.

must be used, and we see that the secondaries of these transformers will have 71 per cent. of the desired continuous-current E. M. F. in a simple alternating and two-phased system, and 62 per cent. of the desired continuous-current voltage in the three-phased system. These values apply to an impressed E. M. F. of sine curve variation. With modern machines, however, these values vary somewhat.

A two-pole generator connected as a single alternating-current converter has two collector rings connected at two diametrically

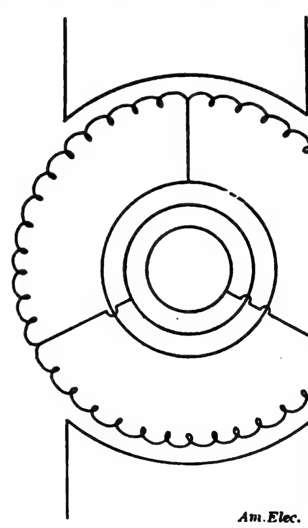


FIG. 3.—TWO-POLE, THREE-PHASED ROTARY CONVERTER.

opposite points of the winding, as shown in Fig. 2.

As a three-phased converter it has three collector rings connected to three equidistant points, as shown in Fig. 3; as a two-phased converter it has four collector rings,

two of which are connected as in the single-current converter, and the other two to points of the windings midway between these, as shown in Fig. 4.

If the continuous-current generator is of multipolar design and series wound, two taps, one opposite a north pole, the other opposite a south pole, are sufficient in a single alternating current converter; three taps at equal distances apart between two pairs of poles in a three-phased; and four taps, two as above in the single-current rotary converter and two others one-half the distance between two poles from these, in a two-phased converter.

In a multiple-wound multipolar generator each pair of poles is considered as an individual machine, and connections made according to rules given regarding the bipolar generator.

A continuous-current generator used as a polyphased rotary converter, not only gives

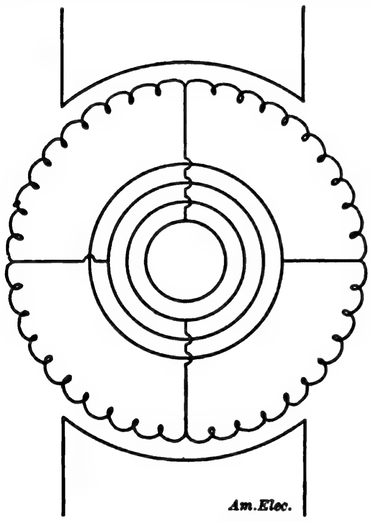


FIG. 4.—TWO-POLE, TWO-PHASED ROTARY CONVERTER.

more output, and thus higher efficiency for same heating, but also, as a rule, commutates better under any condition of load without moving of brushes.

The reason for this high output and good commutation is that in the polyphased rotary converter, the alternating and continuous currents are to a certain extent flowing in opposition to each other, and thus the resultant current and consequently the heating is less than in a corresponding alternator or continuous-current machine. For the same reason the armature reaction, which is dependent upon the resultant current, is also less in a polyphased rotary converter than in a continuous-current machine; or rather, the armature reaction, due to the continuous current taken out of the machine is opposite and approximately equal to that of the alternating current put into the machine. In a single alternating-current rotary converter, however, the heating is more and the commutation not as favorable as for a continuous-current machine.

Rotary converters are thus as a rule preferable to synchronous motors connected to continuous-current generators. Since, however, it is undesirable to have commutating machines running at very high speeds on account of difficulties with the commutators, in isolated cases the use of a synchronous motor driving a continuous-current generator may be preferable. To illustrate this, let us consider a 500-KW, 550-volt rotary converter operated on a 125-cycle circuit.

Let us assume that the speed is limited to 650 r. p. m., the average volts per commutator bar to 15, and the peripheral speed of commutator to 5500 ft. per minute. A 24-pole converter would run at 625 r. p. m., and would thus probably be approved.

The number of commutator segments between each pair of poles must be at least $\frac{550}{15} = 36$, and, therefore, the total number of segments will be $24 \times 36 = 864$. Since the peripheral speed of the commutator was assumed as limited to 5500 ft. per minute, the diameter of the commutator is 33 ins.; thus the width of each segment, adding the insulation between segments, is .12 in., which is too narrow mechanically.

In this case we would either have two or more commutators in series, or, preferably, use a 24-pole synchronous motor driving a 6 or 8-pole direct-current generator.

The limit of frequency depends, not only upon the capacity of the converter, but also upon the voltage; for instance, it may be possible to build a fair 110-volt converter of 500-KW capacity, but impossible to make one for 550 volts in the instance given above.

Rotary converters are designed either with both shunt and series excitation, with only shunt excitation or, finally, without any field excitation whatever.

The first type is preferably used where the rotary converter supplies continuous current to railway circuits, and where the potential at the continuous-current side of the rotary is desired to be constant or increased at a certain ratio with the load, keeping the generator field excitation or generator terminal voltage constant.

The second type—that with only shunt field—is adapted to conditions of lighting where, for instance, the voltage of the converter has to be varied independently of the load. When used for this purpose, regulators or boosters are employed in connection with the rotary converter.

The third type—that without any field excitation whatever—has no advantage over either of the other two types, except as to cheapness of design. If constant voltage is required at the rotary, or if over-compounding is desired, the generator has to be over-compounded.

Rotary Converter with Shunt and Series Excitation.—With this type of rotary converter, not only can the potential at the continuous-current side of the rotary converter be kept constant regardless of load, but can be increased without increasing the field excitation or the E. M. F. at the terminals of the generator. The power factor at the rotary converter and at the generator can be of any desired value, depending upon how much reactance is in circuit between the converter and the generator. As a rule, external reactance has to be added, or ought to be added, if the generator voltage is kept constant and compounding or over-compounding done under these conditions. If, however, the field excitation of the generator is kept constant and thus self-inductance of the latter is added to the line reactance, in most cases it is perfectly feasible to regulate with high power factors without external self-inductance.

This feature is very interesting in so far as self inductance, which usually is considered as objectionable in alternating-current circuits, through causing drop of voltage, is in a rotary converter circuit desirable and even absolutely necessary for automatic control of the voltage—that is, for avoiding drop of voltage under load.

As a practical example let us consider the following problem:

It is desired to deliver 600-KW to a rotary converter 5.7 miles away from the power station at a total loss of about 10 per cent. in step-up transformers, line and step-down transformers.

The voltage at the high-potential side of the step-down transformers is assumed to be 6000, and the frequency 33 cycles. The generator is assumed to have 33 per cent. reactance and running at constant field excitation. The rotary should run at non-inductive load at three-fourths of full load. Find the power factor of the rotary converter and generator at any load.

Assume 5 per cent. loss in step-up and step-down transformers and 6 per cent. resistance; the line loss is thus 5 per cent. At 200 KW for each of the three-phased currents, the loss is 10 KW per wire at

$$\frac{6000}{\sqrt{3}} = 3470 \text{ volts.}$$

The full load current is 58 amps.; therefore,

$$C^2 R = 10{,}000 = 58^2 \times R \text{ or}$$

$$R = \frac{10{,}000}{58^2} = 2.97 \text{ ohms, or } \frac{2.97}{5.7} = .52$$

ohms per mile, which corresponds to No. 0 B. & S. wire. This size wire has .38 ohms reactance per mile at 33 cycles; the total reactance is therefore 2.17 ohms, and the reactance drop is $58 \times 2.17 = 126$ volts, or reactance = 3.6 per cent. We have thus percentage effective resistance = 10, percentage reactance = 33 + .6 + 3.6 = 39.6. Total effective resistance $r = .10$ per cent., total reactance $s = .396$ per cent. = .4. As-

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Let $c + jc_1 =$ the current ($c =$ energy curren $c_1 =$ wattless current);
$u = r - js =$ the impedance in the system ($r =$ resistance, $s =$ reactance);
$e_0 =$ E. M. F. at converter at constan terminal voltage;
$e_0 = e^1{}_0 + kc =$ E. M. F. at rotary at k% over com pounding.
$e^1{}_0 =$ corresp. no load E. M. F.
$e =$ induced E. M. F. at generato when s includes generator reac tance, or the terminal E. M. F. when s includes all reactances between rotary and terminals of generator.
$C_0 =$ energy current at which rotary is non-inductive.

We have then,

$$E = (c + jc_1)(r - js) + e_0 =$$
$$= cr - jcs + jc_1 r + c_1 s + e_0 =$$
$$(cr + c_1 s + e_0) - j(cs - c_1 r),$$
$$\text{or } e^2 = (cr + c_1 s + e_0)^2 + (cs - c_1 r)^2;$$
$$\text{but } e^2 = (c_0 r + e_0)^2 + c_0^2 s^2 \text{ for } c = c_0$$

and thus $c_1 = o$.

By solving these equations we get

$$C = -\frac{s e_0}{u^2} \pm \sqrt{\frac{s^2 e_0^2}{u^4} + (c_0 - c)\left(\frac{2 r e_0}{u^2} + c_0 + c\right)}; \text{..A}$$

$\tan \phi = \frac{c_1}{c}$; is known, and therefore power at rotary, is known;

$$\tan \phi_1 = \frac{e_0 \sin \phi + C s_0}{e_0 \cos \phi + C r_0} \text{ where } C = \frac{c}{\cos \phi};$$

$U_0 = r_0 - js_0 =$ impedance to generator terminals; $\tan \phi_1$ being known $\cos \phi_1 =$ power factor at generator is also known.

suming 5 per cent. loss in rotary and $C_0 = .8$, we have $U = \sqrt{.10^2 + .40^2} = .4125$. Since no over-compounding is desired, $E_0 = i$; substituting these values in A, we get for

$C = .15 = \frac{1}{10}$ load	$\cos \varphi$ = power factor =	47	per cent.
$.3 = \frac{1}{4}$ "	" " "	" 79	"
$.55 = \frac{1}{2}$ "	" " "	" 97.5	"
$.8 = \frac{3}{4}$ "	" " "	" 100	"
$1.05 =$ full "	" " "	" 98.5	"
$1.55 = 1\frac{1}{2}$ "	" " "	" 92	"
$2.05 =$ double "	" " "	" 78	"

for $c = .05$, we get the conditions at no continuous-current output. C, the total current is then .31 or 31 per cent. of full load current and the power factor is 16 per cent. A curve giving this power factor at any load is plotted in Fig. 5.

Assuming that instead of constant field excitation on the generator the terminal voltage was kept constant, the reactance would be only .096 or, say, .1.

A power factor curve of the same plant

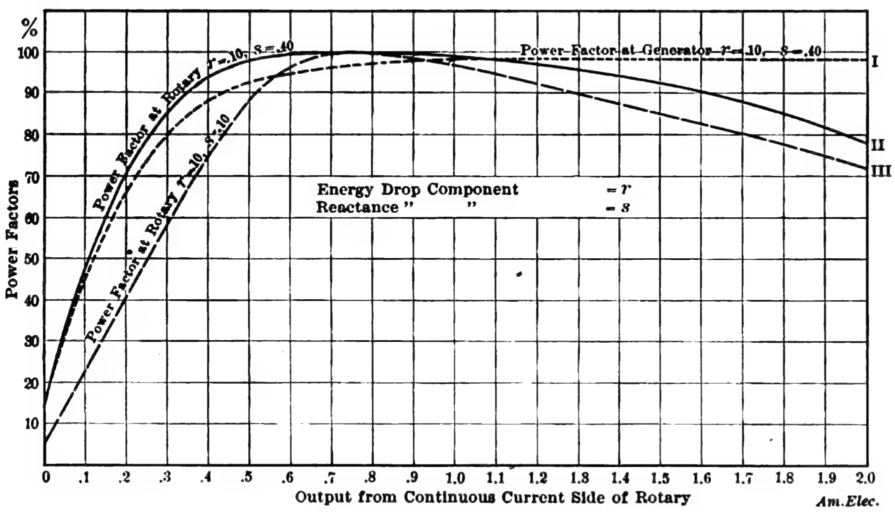

FIG. 5—POWER FACTOR CURVES.

under these conditions is also plotted in Fig. 5. As will be seen, all power factors are considerably lower; when running light the current is 75 per cent. of the full load current, and thus the plant may not be considered entirely satisfactory. To get the same constants as in the case of 40 per cent. reactance ($s = .40$), we have, therefore, to add 30 per cent. artificial reactance. As these reactances can conveniently be open-circuit transformers with one winding only, their sizes will be one-half of corresponding transformer capacity or even less, and the additional cost would thus only correspond to 15 per cent. of that of ordinary transformers. At the generator the power factor is lower at light loads, but higher at heavy loads, since the lagging current at light loads passes over the line reactance and thus causes the E. M. F. to lag still more, and *vice versa*.

In the particular instance given above with a line loss of 10 per cent. ($r = .10$), a reactance of .40 per cent. ($s = .40$), an energy current of .80 per cent. ($c_0 = .8$) when the converter is non-inductive, and with constant voltage at the converter ($c_0 = 1$), the power factor at the generator has the following values:

$\frac{1}{4}$ load,	power factor =	74
$\frac{1}{2}$ "	" "	" 91.6
$\frac{3}{4}$ "	" "	" 96.6
full "	" "	" 97.6
1.5 "	" "	" 97.8
double	" "	" 98

The power factor is increasing, showing that with about 2.5 times full load the generator would run non-inductive.

Rotary Converter with Shunt Field Only.—The tendency of a rotary converter of this type is always to maintain the same amount of wattless current at all loads. Thus, if, for instance, the excitation is so adjusted as to have a non-inductive load at a certain load, the converter will run non-inductive at any other. This is perfectly true at constant impressed E. M. F. and very nearly so at constant generator voltage. Consequently, with a compound-wound generator where the drop in voltage in the line and even the overcompounding of the rotary can be taken care of, this type of rotary is preferable, particularly for lighting or other load that does not fluctuate very suddenly. For a railway load, however, where the load is very unsteady, this type would not be by far as satisfactory as that mentioned having a series and shunt excitation.

Rotary Without Field Excitation.—Since the excitation of this type of rotary converter is obtained by the armature current, it is evident that such a converter must run with lagging currents at all loads. The power factor is therefore, even at full load, comparably low and therefore still lower at the generator owing to the line reactance.

Even with a very small air gap the lagging current is at least 40 per cent. of full load current; at full load, therefore, the power factor of the converter $= \frac{1}{\sqrt{1 + .40^2}} = 93$ per cent.; at half load $= \frac{.5}{\sqrt{.5^2 + .4^2}} = 78$ per cent.; at quarter load $= \frac{.25}{\sqrt{.25^2 + .4^2}} = 53$ per cent.

Thus this type of converter has not the advantage of automatically controlling the voltage or the power factors, and must run at low power factors and small air gap. The advantage, if any, is a somewhat cheaper construction.

The Hedgehog Transformer.

Kapp states that the hedgehog core construction is particularly suitable for choking coils, owing to its capability of allowing large currents to pass under moderate E. M. F., but he considers that the corresponding type of transformer is unsuitable for central station work.

EFFICIENCY OF DIFFERENT TYPES OF THE STEAM ENGINE.

The true efficiency of a steam engine is the ratio between the heat it actually transforms into mechanical work, and that part of the heat in the steam supplied which, under perfect conditions, is *available* for transformation into such work.

With the highest steam pressures now used, less than one-third of the heat in the steam supplied to an engine is available for work, and even with a gauge pressure of 320 lbs. and a vacuum of 26 ins., an engine working in a Carnot cycle without loss—that is, a perfect engine—could only utilize 34 per cent. of the heat supplied.

Frequently the ratio between the heat transformed into work and the *total* heat supplied is referred to as the efficiency of the steam engine, and made the basis of remarks on the woful inefficiency of that machine. This, of course, is absolutely misleading and unjustifiable, for an inexorable law of nature will prevent man from ever utilizing more than a mere fraction of the heat present in steam, while, in point of fact, the modern steam engine is by no means an inefficient machine, as will be shown later.

The part of the heat in steam at a given pressure which is available for transformation into mechanical work in the steam engine, working under perfect conditions and without loss, is very simply determined, being expressed by the ratio of the range of working temperatures to the absolute temperature of the entering steam, which data, knowing the initial and final pressures, can be obtained from the steam tables given in steam engineering and other books. By reference to the same steam table, the number of heat units in the entering steam per pound may be obtained, which, multiplied by the number of pounds per horse-power hour, gives the total heat supplied to the engine. Multiplying this quantity by the above ratio of absolute temperatures gives, finally, the total number of heat units per horse-power that would be transformed into work by a perfect engine; with this number as a denominator and the number of heat units in an hourly horse power as a numerator, we have the fraction expressing the steam working efficiency of the given engine, under perfect conditions.

As an example, suppose we wish to know the steam working efficiency of a non-condensing steam engine operating with a steam pressure of 100 lbs. gauge and a back pressure of 2 lbs., and using 35 lbs. of steam per horse-power hour, the temperature of the feed-water being 60 degs. F.

Referring to Table I, we find that the absolute temperatures corresponding to 2 lbs. and 100 lbs. pressures are 681 degs. and 797 degs., respectively; the working range of temperature is therefore 797 — 681 = 116 degs., and as the entering temperature is 797 degs. the part of heat in the steam supplied which is available for transformation into mechanical work is 116 ÷ 797 = 14.5 per cent. The heat supplied to each pound of water in order to bring it from a temperature of 60 degs. to steam at 100 lbs. pressure is, from the table, 1146 units, and 14.5 per cent. of this will give, near enough for any practi-

cal purpose, the heat units available in each pound of steam for transformation into work under the perfect conditions and without loss. This amounts to 166 heat units, and as 35 lbs. of water are used per hourly horse power, the engine has available $166 \times 50 = 5810$ units of heat for each hourly horse power.

TABLE I.

PRESSURES, TEMPERATURES AND TOTAL HEAT.

Steam Pressure, Gauge.	Temperature Scale, Fahr.	Temperature, absolute, Fahr.	Heat Units from 60° Fahr.
80	324	785	1142
100	338	797	1146
130	355	816	1151
180	380	841	1157
230	399	860	1165
400	447	908	1184
2	220	681	......
Vacuum 26 ins.	126	587	......

The number of heat units per horse-power hour actually transformed into mechanical work is the quotient of the foot-pounds in an hourly horse power by the number representing the equivalent in foot-pounds of a unit of heat, or 778. To develop a horse power for one minute requires 33,000 foot-pounds, and therefore, an hourly horse power is equivalent to 1,980,000 foot-pounds; dividing this quantity by 778 we have, finally, 2544 heat units as equivalent to the mechanical energy of one horse power hour.

We thus have 5810 heat units per horse power hour available for transformation, and the useful work rendered by the engine is equivalent to 2544 heat units. The efficiency with which the engine works the steam supplied to it is, therefore, expressed by the ratio $2544 \div 5810$, or its perfect steam working efficiency is 43.8 per cent.

For comparison with corresponding data in Table II, the approximate coal consump-

TABLE II.

Type of Engine.	Steam Pressure, Gauge.	Pounds of Water per HP-hour.	Efficiency per cent.	Pounds of Coal per HP-hour.
Simple, non-condensing	100	35	43.8	4.09
Simple, condensing	100	18.5	45.2	2.16
Compound	130	15	52.7	1.76
Triple-expansion	180	12	60.6	1.41
Quadruple-expansion	230	10	68.7	1.18

tion may also be approximately calculated. We will assume that each pound of coal contains 14,000 heat units, and that the boiler efficiency is 70 per cent., which values correspond to coal of good quality and an economical boiler. Since, from Table I, 1146 heat units have to be supplied to each pound of water, $1146 \times 35 = 40,070$ heat units will be required per horse-power hour. As each pound of coal burned will furnish $14,000 \times .7 = 9800$ units, the pounds of coal per hour are $40,070 \div 9800 = 3.9$ lbs.

In Table II the practical efficiencies and coal consumption of several types of engines have been worked out in the same manner, all of the necessary data being given in Table I. The consumption of water per hourly horse power given for the condensing engines has been assumed as expressing the best results that have been obtained in practice under the most favorable conditions.

The efficiencies in Table II include the factor due to the higher or lower steam pressures, and are therefore directly comparable, the percentages expressing the actual efficiency with which the steam is worked in the engines. It will be seen that multiple-expansion engines work steam with greater efficiency than the simple engine and, moreover, that this superiority increases with the number of cylinders in which the expansion is carried out. In the case of the quadruple-expansion engine, the losses are but little over 30 per cent., and as some of these are unavoidable, the margin for improvement of the steam engine is not so wide as generally believed.

It will be interesting to know how much the fuel economy of an engine may be expected to be augmented by the use of very high pressures, and as an example, we will assume a pressure of 400 lbs. gauge and make a comparison with the quadruple-expansion engine.

With a vacuum of 26 ins., the range of temperature of a quadruple-expansion engine, working with 230 lbs. steam pressure is, from the table, $860° - 587° = 273°$; as the absolute temperature of the entering steam is 860°, the engine has available for work $273 \div 860 = 31.7$ per cent. of the heat supplied in the steam. For an engine using steam of 400 lbs. pressure this percentage is $(908 - 587) \div 908 = 35.3$ per cent., or the steam of the higher pressure has $35.3 \div 31.7 = 11$ per cent. more heat available per pound of steam. If the engine using the higher pressure had the same working efficiency as the quadruple-expansion engine cited, the consumption of water would be reduced to 9 lbs. On the other hand, if the working efficiency with the higher pressure were the same as that of the triple-expansion engine in the table, which is less by slightly over 11 per cent. than the efficiency of the quadruple-expansion engine, there would be, instead of a saving, a slight loss through increasing the pressure from 230 to 400 lbs.

The conclusion to be drawn from the above considerations is that it would seem wiser to attempt to decrease the coal consumption of engines by increasing their steam working efficiency, than by increasing the range of working pressure. It has been repeatedly shown that this efficiency can be increased through the use of superheated steam, and while it has also been progressively increased by increasing the pressure and adding expansion cylinders, the former method, in view of the practical difficulties involved in the use of very high pressures, would seem to hold out the best prospects for the future.

The above comparisons are made on the basis of engines working in a Carnot cycle, which condition is unattainable in practice, though not theoretically impossible, as is the condition implied when engine efficiences are calculated on the basis of attaining the absolute zero of temperature. In another article similar comparisons will be made on a more practical basis, which will show even higher working efficiencies for the steam engine than here calculated—allowance being made for departures in practice from Carnot's cycle.

THE EARTH AS A CONDUCTOR.

BY DR. LOUIS BELL.

More than half a century ago Steinheil, one of the most distinguished physicists of his time, discovered that if both ends of a telegraph wire were grounded, signals could be sent practically as well as if there were a complete metallic circuit. The importance of this discovery in telegraphic work can hardly be over estimated, since one-half the cost of wire was at once eliminated, and further it soon appeared that the earth was for this purpose so good a conductor that the remaining wire could be much reduced in size, or retaining the same size could be greatly extended without impairing the efficiency of the circuit.

A few years of experience in constructing grounded telegraph lines brought out, too, a very curious fact. It appeared that the excellence of the earth return was substantially independent of the length of the circuit, so that as the lines were lengthened the earth resistance became less and less important and at distances of seventy-five miles or so could practically be neglected. It seemed as if nearly all the earth resistance could be ascribed to the surface resistance at the terminal earth plates. So firmly

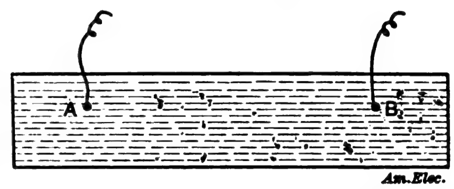

FIG. 1.—LIMITED CONDUCTING MEDIUM.

fixed became this idea that the earth was often spoken of as a conductor of almost immeasureable cross section and of, therefore, almost perfect conductivity.

This was a fairly logical deduction from the premises then at hand, but, as often happens, further experience has quite changed the aspect of affairs.

It is perfectly true that under certain conditions a body like the earth might furnish a conducting path having a resistance independent of its length, but these conditions are in fact very imperfectly fulfilled.

If we have a homogeneous conducting medium of indefinite extent and bury in it two balls, *A* and *B*, which serve as electrodes, then if the distance, *A B*, is very many times the diameterof the balls, the resistance between them does not vary with their distance. In fact it depends only on the size of the balls and the specific resistance of the medium. So long as these do not change the current produced by a given voltage would be the same whether *A B* were a few rods or many miles apart. But if the electrodes remain of finite size the resistance between them cannot vanish.

In this bit of theory lies the explanation of the comparative uniformity of the resistance of the earth circuit, irrespective of distance.

If, however, as actually shown in Fig. 1, the conducting medium available is quite limited in extent the resistance will rise as *A B* increases until when the cross section of the medium in use is only a few times the diameter of *A* and *B* the total resistance will

increase almost directly with the distance, *A B*. If on the other hand, the medium has different specific resistances in different parts the total resistance will change somewhat abruptly as the balls are moved.

Now this earth of ours is curiously constituted. Not only is it remarkably far from homogeneous, but so far as grounded circuits are concerned it is by no means of indefinite extent. In the first place there is a vast difference between the central portion of the earth and the skin on which we live. The earth, as a whole, is about 5⅔ times the density of water, while the average density of the crust is less than half of this, which indicates that the heavy constituents, including nearly all the metallic substances, are near the center, while the surface is made up mostly of a sort of non-metallic slag and the debris resulting from its decomposition.

We are dealing, therefore, in practice, with the least conducting portion of our globe. In fact, it is not putting it too strongly to say that, except for occasional streaks of native metal, the earth as we know it has not even a tolerable conductor in its composition. Even sea water and the best conducting minerals are very poor, and most earthy material has fair or good insulating properties.

The following table shows the specific resistances of divers materials, including a few of the metals. These resistances are given in the manner usual in scientific work; each figure is the resistance in ohms of a cubical block of the substance, 1 centimetre on the edge. Most earthy matter would occupy a place between the last two items in the list, while the solider rocks are, to all intents and purposes, insulators. Except when porous and wet, none of them are of any use as conductors.

Snbstance.	R. ohms per cubic cm.
Silver	0.00000152
Copper	0.00000161
Iron	0.00000982
Mercury	0.00009974
Bismuth	0.0003270
Graphite (max.)	0.002400
Carré carbons	0.003927
Retort carbon	0.066750
Sulphuric acid (max.)	0.8
Concentrated brine	175.0
Wet and dirty wood	200.0
Water	1000.0
Selenium	60000.0
Mica	80000000.0

Hence, when we confidingly thrust a couple of electrodes into the earth they may be practically insulated if they happen to be in loose, dry earth, and when there is sufficient moisture to give a tolerably conducting path between them, this path may or may not be wide enough to render its resistance partially independent of its length.

The earth's crust is largely of stratified structure, rock, clay, gravel, sand, etc. If we make a ground in a liberal bed of wet clay things will go very well; if, however, we strike dry gravel lying over rock there is a very bad outlook for conductivity. It may often happen that the most of the conduction in an earth circuit is via a very shallow stratum. And, in fact, the various strata are often so twisted as to be quite discontinuous.

Fig. 2 shows a section of part of the Appalachian range showing how broken and distorted are the various rock strata of which it is composed. The current flow possible in such a conductor must be very curiously distributed.

It is owing to this extremely heterogeneous make-up that the apparent resistance of an earth circuit is so erratic as we find it. The same diversity of structure shown in the

FIG. 2.--SECTION OF EARTH'S SURFACE.

mountain range may be present within a small area. Under the circumstances it is remarkable that there should be any possibility of getting at even the wildest sort of approximation to uniform results.

If, however, the ground plates employed are in every case of large area—the larger the better—and are sunk into water or wet earth in country not generally dry or rocky, there seems to be a certain similarity in the magnitude of the resistance, independent of the distance between the terminals, showing perhaps that when there is a chance for the distribution of current in wet earth, the properties of the earthy material may get averaged into a sort of homogeneousness.

FIG. 3.—EXAMPLE OF GROUND RETURN.

Some years ago Du Moncel investigated the question of earth circuits and stated that on the average, irrespective of distance, the earth resistance was equivalent to about 7 miles of common telegraph wire, about 85 ohms, under favorable circumstances of grounding.

Now for telegraphic currents this is not a serious matter, for the drop produced through such a resistance by a small fraction of an ampere is insignificant. A few years since, however, attempts were made by various investigators to transmit sensible amounts of power via an earth return. In the early days of electric railways there had been, based upon telegraphic experience, considerable faith in the earth circuit apart from the rails, but these experiments showed it to be ill founded. In two cases at least, attempts were made to utilize rivers as partial returns for electric railway lines, in each

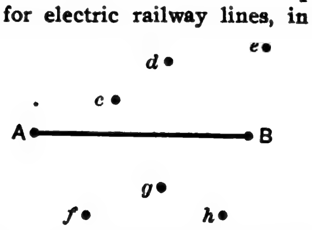

FIG. 4.—GROUND RETURN OF LONG ELECTRIC LINE.

instance between four and five miles in length. The event showed that for this purpose the earth was totally useless. The terminals employed were amply large and in most favorable situations, but the resistance of the returns proved to be between 80 and 85 ohms, and was but slightly affected by grounding at intermediate points. Another very instructive example of ground return work is given in Fig. 3. Here the distance, *A B*, is 3000 ft. divided into six nearly equal sections by the intermediate grounds 1, 2, 3, 4, 5. At the termini were very thoroughly-made earth connections in duplicate, so that one pair or both could be used.

The result was somewhat startling, but quite what we should be prepared to expect. The resistances were as follows:

A . . . 1	201.6 ohms.	
A . . . 2	374. "	
A . . . 3	92. "	
A . . . 4	506.3 "	
A . . . 5	180. "	
A . . . *B*	92.4	First pair of grounds.
A . . . *B*	121.	Second " " "
A . . . *B*	66.8	Both sets.

These resistances varied but slightly with the voltage used, and with continuous, or alternating currents. One of the curious features of this test is the very low resistance *A* . . . 3.

From all the data available it appears to be difficult to extort from earth connections at any reasonable distance apart a resistance much below 75-80 ohms, and considerable variations in distance do not seem greatly to affect this figure. Increasing the size and improving the contacts of earth plates lowers the resistance, but not in any definite ratio. So much for the relation between our theoretical infinite homogeneous medium and our practical earth.

Now having such conditions of resistance what use can be made of the earth circuit. In the first place it is evidently all right, as has long been known, for telegraphic and telephonic purposes. For railway and ordinary motor purposes it is absolutely worthless, for with any practical current the drop is enormous. In fact, so far as electric railways are concerned, not only is the earth of no value as a conductor, but whatever current gets into the earth is likely to cause electrolysis. It is interesting, however, to consider what might be done at very high voltages. At 50,000 volts a current of 10 amperes would deliver between 500 and 600 mechanical HP. Assuming a grounded circuit and an earth resistance of 100 ohms, the loss due to this would be 1000 volts, only five per cent. of the working voltage, and allowing a similar loss in the line, the energy in question could be transmitted something like seventy-five miles over a common telegraph wire. The possible effect of such an operation on other grounded circuits in the neighborhood can better be imagined than described.

There has been a good deal of discussion as to what happens to a grounded current. Does it in any sense preserve its integrity or is it simply pumped into an immense reservoir of zero potential? Speaking in view of the actual conditions, neither idea is correct. Possibly the following analogy will give a clearer perception of what happens:

Imagine a huge tank partly filled with water and let two points in it be connected by a pipe in which is a force pump. Now fill the tank with broken stone, gravel, old tin cans, brickbats, anything that comes handy, and work the pump. The water will circulate in the tube in a definite way, but the lines of flow in the tank defy description. The flow follows accurately the strokes of the pump and in the tube it can readily be traced, but in the tank the most that can be said is that the outflow of the tube and the inflow at the other end are equivalent. Signs of flow can be detected

all through the tank and in almost any direction you please.

If a long electric line is grounded at both ends and put into service, current flow can be obtained between almost any points in the vicinity. If the main circuit is *A B* (Fig. 4) there will in all human probability be differences of potential between any two of the points *c, d, e, f, g, h*. In fact, it would be difficult to find any two points tolerably far apart in the region around *A B* which when connected would not give a current due to that in *A B*. Hence, if there is a great difference of potential between *A* and *B*, so as to give considerable variations of potential in the neighborhood, current can be obtained between, for instance, the points, *g h*, even if they are a considerable distance from *A B*.

Since the current in *g h* varies with the fundamental current, *A B*, this derived current responds to signals sent over *A B*. This property has been used for telegraphy without wires between the points exchanging signals. For example, *A B* might be ten miles long and separated by a river from *g h*, nevertheless telegraphic signals could be sent over *A B* which would be audible in a telephone inserted in the line *g h*, a telephone being used as a receiver on account of its extraordinary sensitiveness. This is practically the only use that has been made of the earth as a conductor other than for a return circuit.

From what has gone before it is clear that the conductivity of the earth is so meagre that save in the case of very high voltages or very minute currents it is quite insignificant in practical affairs. In railway return circuits one deals with the track alone so far as is possible and earth currents from this source do much more harm than good. For power service the earth is useless as a return under existing limitations of voltage and public endurance, and in telegraphy alone does it appear likely to serve a permanently useful purpose.

DRILLING GLASS.

A correspondent sends us the following particulars concerning the method he used in drilling holes of considerable diameter in glass disks, which were used in making a Wimshurst machine after the instructions given in the November number of the AMERICAN ELECTRICIAN:

A brass tube, emery and turpentine and an improvised fiddle-bow drill were used. The sheet of glass was placed on a pine board whose surface was practically a plane; another piece of ⅞ in. board—in which was a hole as a guide for the brass tube—was placed over the glass, and the boards and glass held to a table by hand screws. The brass tube had a wooden knob in one end, to hold in the hand while using the fiddle-bow drill. Three holes were made—one with dry emery, which chipped round the edges; one with emery and water, which was better than the dry boring. The third hole was drilled from one side of the glass in 15 minutes, with about No. 120 emery moistened with turpentine. In this case the sides of the hole were remarkably true and smooth, and this method is recommended for drilling glass.

SAVING OF COPPER IN THREE-PHASED TRANSMISSION LINES.

The analytical method of calculating the comparative amounts of copper required for three-phased and for single alternating-current systems is rather complex, but, fortunately, this determination may be very simply arrived at by a mere consideration of the sine curves representing the variation of current or E. M. F.

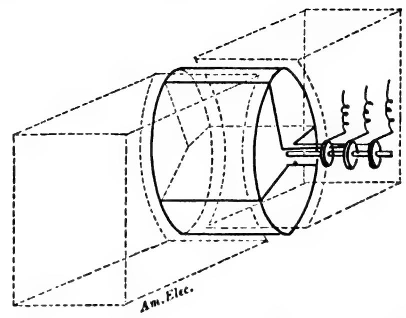

FIG. 1.—ELEMENTARY THREE-PHASED ALTERNATOR.

As such expressions as "A three-phased current" have passed largely into use, it may not be amiss to clearly define a three-phased system before entering upon the main purpose of this article. In Fig. 1 an

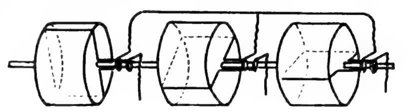

FIG. 2.—THREE SIMPLE ALTERNATORS, FORMING A THREE-PHASED GENERATING UNIT.

elementary three-phased alternator is represented, consisting of an ordinary drum armature in a bipolar field, with three conductors on its surface spaced 120 degs. apart; the three conductors start from a common point, and an end of each connects to a collector ring.

When the armature revolves, it will be seen that each conductor will be cutting the lines of the field at a different rate from the others (except in two certain positions of the armature), and therefore will have generated in them at any instant E. M.Fs. of different value. For example, when the plane of one conductor is vertical it will have no E. M. F., while one of the others will have almost its maximum positive E. M. F., and the other a negative E. M. F. of the same value. Similarly, if the plane of one conductor is horizontal, that conductor will then have its maximum E. M. F., and the other two equal E. M. Fs., one increasing and the other decreasing, but of opposite sign to the E. M. F. of the first conductor.

In other words, each conductor will generate its own E. M. F. independently of the other, and the system is equivalent to three independent and similar machine working at the same speed. This is shown in Fig. 2, which represents three alternators with their shafts rigidly coupled and in such a manner that the coils of each bear the same relation to each other and their respective fields as is shown in Fig. 1. If a ring on each alternator has a common connection, as shown, the analogy is complete, and though each alternator will work, (if the load is equally distributed between the three outgoing wires), precisely as a simple alternator, each generating its own current as if it had no connection with the others, the system as a whole is a three-phased one. This is not a mere hypothetical case for, in point of fact, a three-phased system consisting of three simple alternators thus connected would in some respects be an ideal one, as, since the fields are separate, regulation in case of lack of balance could be perfectly effected, which cannot be done with the typical three-phased generator with its single field for three generating circuits.

In Fig. 3 are shown some curves in the proper phase relation to represent the relation of the several currents or E. M. Fs. of a three-phased system at any instant of time; by means of these curves an interesting property of the three-phased system may be illustrated. If we draw a vertical line, such as *M N R S*, at any point, it will be found that, for example, the length of the portion, *M N*, on one side of the axis of the curves, is always equal to the sum of the portions of the same line intercepted by the two curves on the other side, or $MN = NR + NS$. That is, *in a three-phased system, each of the wires alternately acts as a return or a lead for the two other wires.* In the figure, the wire corresponding to the curve, *B*, acts as a return for *A* and *C* from *a* to c_0; the wire, *A*, as a lead for the wires, *B* and *C*, from c_0 to *b*, and so on.

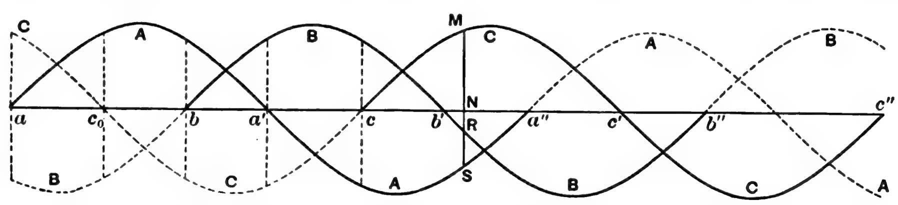

FIG. 3.—SHOWING PHASE RELATIONS BETWEEN E. M. F. OR CURRENT CURVES OF THREE-PHASED SYSTEM.

The above property enables a comparison of the three-phased and simple alternating-current systems, with respect to copper, to be very simply made. In Fig. 4 the two systems of distribution are represented, each carrying the same number of lamps. In the

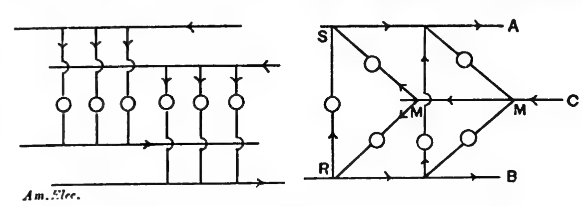

FIG. 4.—SIMPLE ALTERNATING AND THREE-PHASED CIRCUITS.

simple alternating system six lamps are connected to four wires, and in the three-phased the same number of lamps is connected to three wires. The same energy passes over the wires in each case; that is, the currents in each of the wires have the same mean energy value. In one, however, there are necessary two leads and two returns to convey the energy, while in the other, since a single wire alternately acts as a lead or return for the other two, there is a saving of one wire. That is, the three-phased system only requires three-fourths or 75 per cent. of the copper to transmit the same energy, with the same loss, as the simple, or single alternating-current system.

Though having nothing to do with the saving of copper, another interesting property of the three-phased system may here be pointed out. In Fig. 5, *A* and *B* represent the E. M. Fs. in any two of the wires of a three-phased system, being represented in their proper phase relation, and with respect to *the potential of the neutral point of a three-phased winding*, mentioned in connec-

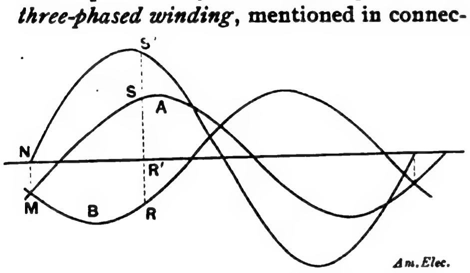

FIG. 5.—SHOWING RELATION BETWEEN THREE-PHASED ARMATURE AND LINE E. M. F.

tion with Figs. 1 and 2. If, now, we plot, for each joint in the axis, the difference of potential between the two wires, we get the curve, *NS'*, which represents the E. M. F. *between any two of the distributing wires.* That is, if, for example, the E. M. F. in each wire, with respect to the neutral point of the several wires, is 1000 volts, it is $\sqrt{3}$ times this, or 1732 volts, between the line wires. In other words, by connecting the neutral point of the winding of a three-phased machine to a fourth ring and running from it a fourth wire, consuming devices may be connected between this fourth wire and each of the main wires, making a system of six cir-

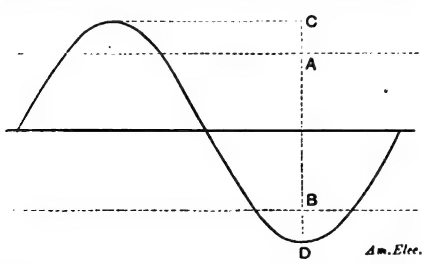

FIG. 6.—SHOWING RELATION BETWEEN EFFECTIVE AND MAXIMUM E. M. F.

cuits with four wires; three of these circuits will then have an E. M. F. of, say, 1000 volts, and three an E. M. F. of 1732 volts. The 1000-volt circuit may be employed for lighting while the main circuits are being used for power.

The saving in copper above deduced refers to equal amounts of electrical energy transmitted with the same line loss, or, in other words, on the basis of the effective E. M. F. We will now make the comparison with respect to equal maximum stress on the insulation, or the stress due to the maximum, and not effective, E. M. F.

In Fig. 6, if *D C*, represents the maximum E. M. F., *A B* will represent the effective E. M. F. That is, if the maximum E. M. F. is 1414 volts ($\sqrt{2} \times 1000$) the effect which will be produced in overcoming any

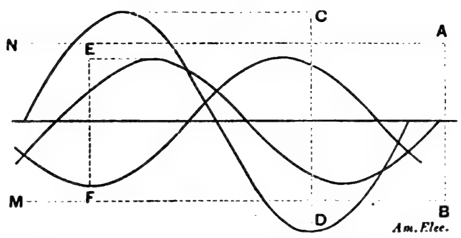

FIG. 7.—SHOWING RELATION BETWEEN EFFECTIVE AND MAXIMUM E. M. Fs.

resistance is only equivalent to the effect of a constant current E. M. F. of 1000 volts. Therefore, an alternating-current E. M. F. to do the same work on a given circuit as a continuous-current E. M. F., will have the same effective value as the latter, but will produce a dielectric strain in the line insulation 1.4 ($\sqrt{2}$) times greater. Consequently, to bring the strain the same, the alternating E. M. F. will have to be reduced in the proportion of $1 : \sqrt{2}$; but, since the comparison is on the basis of equal energy transmitted, the alternating current will thus have to be increased over the continuous current in the proportion of $\sqrt{2} : 1$ As, however, the line loss varies as the square of the current (C^2R), this loss will be ($\sqrt{2})^2 = 2$ or doubled; finally, to bring the comparison to the basis of equal energy transmitted with equal loss, the simple alternating current system will require, on the basis of equal electrostatic insulation strain, twice as much copper as the continuous-current system.

In Fig. 7 the line, *E F*, represents the maximum E. M. F. that would subsist between any three-phased wire and the ground if the neutral point of the winding were grounded; *C D*, the E. M. F. between any two line wires, and *A B*, the effective E. M. F. of the line. Leaving aside the first case which, though curious, has no practical importance, the relation between the maximum and effective insulation strain is the same in the three-phased as in the single alternating-current system, being the ratio of the maximum and square root of mean square ordinates, or $\sqrt{2} : 1$. But the three-phased system requires, for the same line loss and amount of energy transmitted, only 75 per cent. of the copper of the simple alternating system employing the same voltage. Since the voltages are the same, the dielectric stress in each system is the same, while the three-phased system retains its superior copper economy. Consequently, both on the basis of effective and maximum voltage, the three-phased system entails a saving of 25 per cent. in copper over the simple alternating system.

It should be added that the saving in the three-phased system on the basis of effective E. M. F., is the same over the continuous-current system as over the simple alternating system. While this conclusion is apparently to the disadvantage of alternating currents, practically it is not, for at high voltages the continuous current is out of the race; besides, as, Steinmetz has pointed out, the electrolytic strain of continuous currents is much more injurious to insulation than the increased electrostatic strain due to the maximum value of the E. M. F. of alternating currents.

THE CAUSE OF CHANGE OF MICROPHONE RESISTANCE.

BY PROF. REGINALD A. FESSENDEN.

May I be permitted to call attention to the fact that the cause of the change of microphone resistance has been, I believe, conclusively determined by direct experiments. In 1891, whilst working upon a system of multiple telegraphy, I was led to perceive that the sine form of wave was an important factor in rapid and undistorted transmission. The question then arose, "Does the telephone transmitter give such a wave form, and if not, may possibly some other substance give better results than carbon.

Two of my students, Messrs. Ross and Dougherty, took up the question and carried out the experiments in a very admirable manner. The following materials were tested, amongst others: Carbon rods and plates of varying hardness and of varying dimensions were tested under tension and pressure of varying amounts; lampblack, graphite, charcoal, carbon powder, and steel bicycle balls were tested under different pressures, and with different current densities. Curves were plotted showing the relation between the force applied and the resultant change in resistance.

The results showed very plainly that the sole and only change of any importance was due to change of surface contact, and that neither pressure nor heating produced any effects of comparable amount, though some very slight effects were observed. These experiments were presented as a thesis by Messrs. Ross and Dougherty at Purdue University, in 1893.

Some subsequent experiments made by myself have shown that some other circumstances have a vital importance. For instance, the oxide formed by the substance used for a contact must be a gas, or else a conductor, if satisfactory and coherent results are to be obtained in use. This limits us to the following materials: Carbon, osmium, lead, lead sulphide, manganese, and possibly impure sulphur. If, however, the material be kept in an enclosure, then chlorine gas may be used instead of air, and all substances forming gaseous chlorides may be used. Granulated lead peroxide and manganese peroxide might also be used, or a mixture of these with carbon.

I have not tried all these materials, and it is possible that some of them might be valuable. Those I have tried, however, were inferior to carbon, mainly, I conceive, because carbon is so much more elastic that the small prominences which make the contact can stand considerable distortion without breaking.

Possibly some of the readers of the AMERICAN ELECTRICIAN know whether transmitters have been tried, made up of carburized thin velvet or Brussels carpet, or of velvet made from celluloid silk. It seems to me that good transmitters might be made with a small pile of disks of any of these materials.

THE MILWAUKEE CONVENTION OF THE NORTHWESTERN ELECTRIC LIGHT ASSOCIATION.

The Fifth Annual Convention of the Northwestern Electric Light Association which was held in Milwaukee, on Jan. 20 and 21, was one of the most important meetings that body has yet had. While a number of interesting papers were read on various subjects, the greater part of the time of the meeting was taken up with the discussion of the question of municipal electric lighting, which was also the subject of two committee reports and of a paper by Mr. John Schuette.

Owing to illness, Mr. W. B. Baker, president of the Association, was unable to be present, and the chair was occupied by Mr. H. C. Higgins, second vice-president. The report of the secretary showed that the Association is in fine condition, and the excellent prestige which it has acquired in its territory was shown by the large number of applications for membership, over thirty new members being added.

The following officers were elected for the ensuing year: President, Mr. H. C. Higgins, of Marinette, Wis.; first vice-president, Mr. G. L. Cole, of Beloit, Wis.; second vice-president, Mr. J. H. Harding, of Laporte, Ind.; board of directors, Messrs. E. L. Debell, of Sheboygan, Wis.; O. M. Rau, of Milwaukee and W. W. Bean, of St. Joseph, Mich. La Crosse, Wis., was named as the place of meeting for the next convention of the Association.

A pleasant episode of the Convention was the presentation to Secretary Thomas R. Mercein of a handsome electrical emblem in the form of a gold circlet with a large solitaire diamond set in its center. The presentation address was gracefully made by Mr. James Wolfe, of Chicago, who echoed the sentiments of all the membership of the Association and others who have had official and personal relations with its secretary, in the complimentary allusions he made to Mr. Mercein's efficiency and unvarying courtesy.

MUNICIPAL ELECTRIC LIGHTING.

A special committee appointed at a previous meeting of the Association on the matter of municipal ownership of plants, submitted two reports, a preliminary report read by Mr. H. L. Doherty, and another read by Mr. Elihu Coleman.

The reports referred to the growing strength of the movement against existing central stations in favor of plants installed and owned by municipalities, which movement was believed to be strengthened by the attitude of manufacturing companies, who abet the installation of municipal plants without openly showing their hands. It was suggested that a committee be instructed to report at each meeting the number and location of municipal plants installed, and the names of the manufacturers furnishing the steam and electrical apparatus. The committee was of the opinion that, in order to investigate the results obtained from municipal plants already established, it will be necessary to send a capable representative to make a personal investigation on the spot, as the reports issued by the towns and cities on the subject are entirely unreliable, many of the electric light expenses, in cases, being charged under other heads, while in but few instances are items for interest, depreciation, taxes, water and office rent, management, fire insurance, employe's liability insurance and general risk, included. The injustice was referred to of cities granting franchises carrying obligations binding both parties, and then entering the field with a plant of its own. A municipality should not be given the power to put in a plant unless the existing companies shall be bought out, or their stock bought up, or, if an agreement of purchase cannot be made, the application of a process of condemnation similar to that exercised in the power of eminent domain with respect to railroads.

As to the questions whether municipal ownership is practicable and whether it will be remunerative, it was maintained that the office of the town or city is to do for its citizens such work as individuals or corporations cannot do for themselves, and that with respect to furnishing water and lights, this can better be done by a quasi-public corporation than by the city itself, franchises being given to such corporations to relieve the city of the burden of further and undesirable additions to its body of employes.

Many other undesirable features were referred to, such as management by commission with its lack of knowledge of the subject, the temptations in the purchase of machinery and supplies leading to corruption, the opportunities for showing favoritism by rebates, the probability of consumers taking undue advantages that would be impossible with a private corporation, etc. The conclusions are that the legislature should grant no powers to municipalities to erect and maintain lighting plants for general use unless those holding franchises shall be remunerated for their cancellation; that electrical manufacturers should not sell to municipalities until these steps have been taken, and central station men should not deal with manufacturers who act otherwise; and that those opposing municipal ownership should devote their efforts to showing that the business will be unprofitable if taxes and other items are included.

A paper on the same subject, by Mr. John Schuette, laid stress upon the false character of the estimates made by advocates of municipal ownership concerning the actual cost of electric lighting, and stated that the most serious objection to municipal ownership lies in the increased temptations it offers for political corruption, both directly and as tending to increase the formation and maintenance of rings. The duty of all persons interested in electric lighting is to stand as a solid body to defend themselves and each other against all unjust legislation which may be attempted against their interests. Mr. Schuette called upon the Northwestern Electric Light Association to show a bold front, and recommended that the expense attending such a defense should be borne out of a general fund, to be obtained by assessing each central station in proportion to its kilowatt capacity, and with the proceeds employing a representative whose duty it shall be to attend the sessions of the legislature in order to keep those interested informed as to the course of legislation and the best means to meet unfavorable measures.

The subject of municipal ownership was lengthily discussed in the proceedings. Mr. W. J. Buckley considered that the best way of combating the danger was, as suggested by the committee, to obtain data for presentation to municipal bodies which would convince them that they cannot afford to establish a municipal plant. He also advised that central station managers should cultivate the acquaintance of the members of municipal governing bodies in order to be in a position to most advantageously present their side of the case.

Mr. Coleman considered that the manner in which central stations had been conducted in the past had much to do with the attacks now made against private ownership. He mentioned one case where a plant in which not more than $50,000 was invested was bonded for $400,000, stocked for $400,000, and notes issued for another $100,000. He believes that if the matter is put before the people in the right way as a business proposition, they will be enabled to thoroughly understand the situation, and trouble will thus be minimized.

Mr. W. W. Bean was also of the opinion that it is necessary to get correct figures and then present their case straightforwardly and truthfully; if, after that, the people are not convinced, he would advise getting out and going into some other business. He did not agree with Mr. Buckley in regard to becoming better acquainted with city councilmen, but thought it best to present to governing bodies plain and clean-cut propositions, and let these speak for themselves.

Mr. H. T. Pierce, of Negaunee, related in detail the course of an attack on the central station in his town which, however, thus far had been rendered ineffective by injunctions granted by the courts. As an illustration of municipal mismanagement, he stated that while the poles for the projected municipal lines were specified to be 35 ft. long, the first shipment received consisted almost entirely of 15 ft. poles!

After a long discussion on the subject of protection from legislative attacks on central station interests, a committee of three members was appointed to take charge of the matter.

ELECTRICAL FIRE HAZARD.

Mr. George S. McLaren read a paper on "Insurance as Affected by Electrical Construction," in which the subject was presented from the standpoint of the insurance interest. He believes that the more insurance companies insist upon good, practical, safe wiring and proper use of electrical apparatus, the better it will be for central station owners, supply men and others concerned. Owing to the careful inspection of electrical equipments by insurance inspectors, the central station manager can turn the current on with the assurance that the work has been properly done, and thereafter have the satisfaction of knowing that periodical insurance inspections will see that it is maintained in good condition; on the other hand, the person owning the building feels that he has some one constantly looking out for his interests, while the supply men and con-

tractor are aided, since the underwriters are always ready to recommend the best goods and the most reliable workmen. He asked the aid of the Association in raising the standard of electrical work and electrical workers by encouraging the employment of good, reliable men instead of cheaper irresponsible labor.

Mr. McLaren recommended that the Association should endeavor to get a legislative act passed requiring all electrical workers to pass examinations before they could take part in insulation of electrical equipment.

Mr. H. L. Dogerty criticised this proposition, believing the situationis better as it is, under which the central station manager can have the work done by any one, and can fully protect himself.

Mr. Debell favored the proposition, though he believed it would not be entirely necessary, as central stations can refuse to connect their wires to circuits if not properly installed.

Mr. Cutter opposed the legislation suggested. He considered that insurance and central station interests are really almost identical, and at present are working nicely together.

Prof. D. C. Jackson said he had found that not only do a large proportion of contractors for wiring know very little of the details of the underwriters' code, but that even employes of central stations who have the inspection of wiring after the contractors put it in, are not acquainted with the requirements. He considers that central station managers do not pay sufficient attention to many small details, and recommended that they drill their employes in the requirements of the underwriters' code.

Mr. Grover said that since central stations have the privilege of examining every job before connected up, if poor wiring is done there is no reason why the central station should accept it, and, consequently, that the owner should pay for it.

Mr. Copeland said his company found it advisable to go out of the wiring business, which is now done by outside contractors; their work is inspected by the superintendent of the central station, who declines to turn current on if it is not in proper condition.

Mr. Harding said that his company has no difficulty in getting wiring properly done by outside contractors.

INCANDESCENT LAMPS.

Mr. F. S. Terry read a paper on "Incandescent Lamps," in which he referred to the absurdity of offering a guarantee for the life of a lamp, since the conditions governing such life are under the control of the one operating the dynamo, and furthermore, the length which the lamp will burn is a factor of small relative importance in determining economy in incandescent lighting. Every manufacturer can make long-life lamps, and those that are inferior in quality will usually be found to have a long-life. The real measure of the efficiency of a lamp is the rate of decline of the candle power. The term "useful life" is more appropriate, since it means the time in which the candle power has declined so as to give an unserviceable light, which useful life, in most cases, is as long as the light in within twenty-five per cent of the initial candle power. The initial efficiency of a lamp does not signify much, the real efficiency being the average light obtained for the energy consumed during the useful life.

The importance of uniform voltage was dwelt upon and the consequent desirability of using a good station voltmeter. It was pointed out that over-running a lamp not only shortens its life, but increases the resistance of the filament so that it will not afterwards give its normal candle power at its normal voltage.

Referring to the advocacy of 2 and 2½-watt lamps, Mr. Terry stated that all stations possessed such lamps now, it being only necessary to increase the voltage to obtain high efficiency, but the useful life would be less. Two and one-half-watt lamps could not be used now on most central stations circuit, owing to lack of regulation, since fluctuations will injure so-called high-efficiency lamps much more than those of so-called lower efficiency. Mr. Terry considers that the 3½-watt lamp will give the best satisfaction in most moderately sized stations as now operated.

HEATING AND COOKING BY ELECTRICITY.

Mr. George Cutter, of Chicago, called attention to a few of the many electric heating appliances now regularly on the market, giving data concerning the same. Referring to 110-volt circuits, a 6½-lb. sad iron for common household use requires 4 amperes, or for laundry use where the work is rushed, 5 or 6 amperes; a polishing iron requires 2.5 amperes, and an 18 lb.-goose iron 5 amperes; a 4½ in.-plate stove requires 1.9 amperes, which current will make it hot in about two minutes. A larger disk heater, 6 ins. in diameter, requires 5.5 amperes; a single griddle requires the same current, and a 3-section griddle requires 6 amperes; a chafing dish will take 4 amperes and small tea kettles require from 4 to 7 amperes; an immersion coil for cooking food, boiling water and for heating water for special work takes from 4 to 8 amperes, according to size; a heating pad for application to the body uses only .4 amperes, which is the same current required for a curling iron.

Mr. Cutter considers that every central station manager should familiarize himself with the heating and cooking apparatus now on the market, and should arrange to show the apparatus in operation so as to create a public interest in it; he should also study the question of rates, so as to be able to offer special inducements for a more varied use of the current, and should educate his patrons to use the current economically, and insist on the use of devices which are efficient and durable.

ELECTRICAL SUPPLIES.

In a paper with this title Mr. W. W. Low sketched the history of the electrical supply business. He referred to the fact that it is comparatively a few years since key sockets were sold at $1.25 apiece. The price of single-pole wood cut-outs, costing seven cents to make, was seventy-five cents, and incandescent lamps were sold for eighty cents in thousand lots; at present key sockets are sold for ten cents, and high grade double-pole, covered porcelain cut-outs for the same price, and all other supplies in like proportion. He dwelt upon the importance of purchasers giving proper specifications with their orders, and quoted one case where telegraphic orders were received for 1000 ft. of No. 10 wire, and another for one barrel of incandescent lamps, no information being given concerning the insulation of the wire, nor the voltage or base of the lamp. He stated that between thirty and thirty-five per cent. of orders received have to be held until further information is secured.

ELECTRICAL SAFETY DEVICES.

Prof. W. M. Stine, of Armour Institute, read a paper in which he considered the subject of fuses and other protective devices for electrical circuits. His conclusions with respect to fuse wire cut-outs are that covered fuses are more sensitive and have a lower capacity than exposed ones; fuse wires should be rated for their carrying capacity in terms of the lengths ordinarily employed; fuse blocks should be made with proper distances between the terminals, and fuses should be renewed from time to time as they become coated or fouled. Time elements should be considered when the fuse protects apparatus liable to burn out.

Fuses up to 5 amperes should be at least 5½ ins. in length, and 1½ ins. should be added to the length for each increment of 5 amperes; except for smaller sizes, flat fuses are more reliable than round wires, and the latter should not be employed in excess of 30 amperes capacity, flat ribbons exceeding 4 ins. in length being used for higher currents.

Prof. Stine considers that the ordinary method or rating fuses is entirely inadequate. Each spool of wire should be accompanied by a curve or table clearly setting forth the carrying capacity for varying lengths. He thinks, however, that it would be best to discontinue the use of wire and only use fuses solidly mounted on terminals plainly marked with their normal rating, which should be at least 80 or 90 per cent. of their fusing currents. The screw fuse plug is strongly condemned, not only on account of the short length of the wire, but also because of poor workmanship and liberal use of solder; as a rule their actual fusing points are double their marked ratings.

The greater reliability with respect to time element, of the mechanical cut-out over fuse wire was illustrated by a table. With currents increasing from 26 amperes io 73 amperes the mechanical cut-out broke the circuit in every instant in less than a tenth of a second, while a fuse wire marked for 25 amperes carrying capacity required 300 seconds with 26 amperes, which time greatly decreased with higher strengths of currents, reaching 4.8 seconds with 80 amperes. As to when fuse wire and mechanical cut-outs are to be used, it is recommended that fuse wires be kept off switchboards entirely, as they do not afford the reguisite protection and besides, foul the boards; for protecting motors, except in the smaller sizes, fuses are not reliable, and circuit breakers should invariably be used, and the same applies to the protection of transformers, though at present the latter suggestion, he stated, seems rather impracticable. For such places as distribution boxes and tap circuits, the fuse wire leaves

little to be desired, and it would be well were it confined to such uses exclusively.

Among other papers read were one by Mr. N. W. Perry on "Gaseous Fuel," and another by Mr. Caryl D. Haskins on "Röntgen Rays," which latter was illustrated by projected views. A paper was also read by Mr. Herbert C. Wirt on "Protective Devices for Transformers," which will appear in another issue.

DYNAMO CHARACTERISTICS.

BY PROF. WILBUR M. STINE.

No intelligent and progressive steam engineer needs, now-a-days, to be presented with a long array of arguments to convince him that a steam engine indicator is not only a good thing to possess, but that his engine is run properly only when such indicator is frequently used. This intelligent condition of affairs is a matter of but the past few years. The indicator was considered as fit only for the laboratory, to be used by theoretical investigators, and on no account should it be introduced into a practical engine room. The great changes in such sentiments which are now occurring must be very largely ascribed to the influence of technical journals. The intelligent steam engineer is constantly seeking to extend his knowledge of his occupation, and the leading technical journals are showing rare enterprise and doing an admirable work in supplying the desired information. The laboratories for testing and investigation contained very many things of a practical character, which can be so presented and conformed to the needs of practice that a general knowledge of such matters cannot fail to be of value.

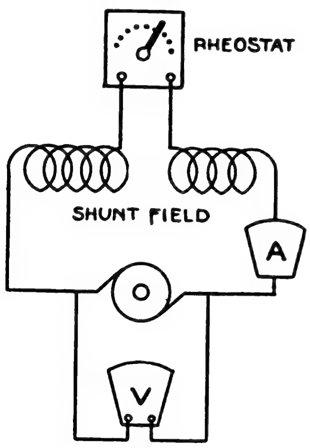

FIG. 1.

No doubt the same intelligent interest on the part of electricians who are constantly employed about dynamos has suggested the desire for some means to indicate the dynamo. When an engine runs badly, the indicator may point out a bad setting of the valve; when a dynamo sparks viciously, is there no means to obtain a curve which shall suggest a remedy?

In the testing laboratories of the electrical manufacturing companies and of the technical schools, dynamos are indicated with a precision and thoroughness which far surpasses that possible with a steam engine. Some of these processes would be obscure to those who have not had a wide training in electricity and magnetism, but most of them are of such a practical nature, and based on elementary principles, that they should become the subject of general intelligent interest.

The dynamo characteristic is a curve designed to show quantitatively some particular phase of the behavior or operation of the machine. It is, for the most part, a purely electrical or magnetic property that is outlined. The essential members of the direct-current dynamo are the field, armature and commutator. The strength of the field is dependent upon the amount of current in its windings. Just what this relation is can be readily seen from a properly plotted characteristic. If the dynamo be compound-wound, the relative influence of the shunt and series coils becomes apparent. Such curves will also show the operation and losses in the armature; how the voltage of the dynamo is distributed around the commutator; and how much latitude there is for setting the brushes to secure sparkless commutation. The characteristics of the compound-wound, direct-current dynamo will be here described.

Characteristics of the Compound-Wound Dynamo.—The present discussion will be based on data obtained from a small dynamo. It was a bipolar machine, wound to deliver 125 volts at the brushes at a speed of 1375 r. p. m.

The first curve noticed is one which will give an intelligent answer to a question often asked. It is called the speed characteristic, and shows how the E. M. F. changes with the speed under certain conditions. The dynamo generates its voltage, due to the conductors cutting lines of force at a certain rate, one volt being generated when the lines of force are cut at the rate of 100,000,000 lines per second. If the field is kept constant, the rate at which the lines are cut will depend directly upon the speed. This the curve clearly shows. The connections for obtaining this curve are shown in Fig. 1. Two instruments are needed for the test. For such work only one class of instruments are suitable, those having equally spaced scales, such as the Weston ammeters and voltmeters. In the Fig. *H* is an ammeter of suitable range to read the current usually flowing in the shunt coil; and *V* a voltmeter connected to the brushes. The dynamo is to be run on open external circuit. If the dynamo is so connected up that the shunt current also passes through the series coil, it will make no difference. A rheostat is placed in the shunt circuit as shown. It may be the regulating rheostat of the dynamo, but for wide range of adjustment, it is better to put some other rheostat resistance in series with it. The speed of the dynamo is read by means of a suitable speed indicator at each reading of the voltmeter. The test should begin at as low a speed as

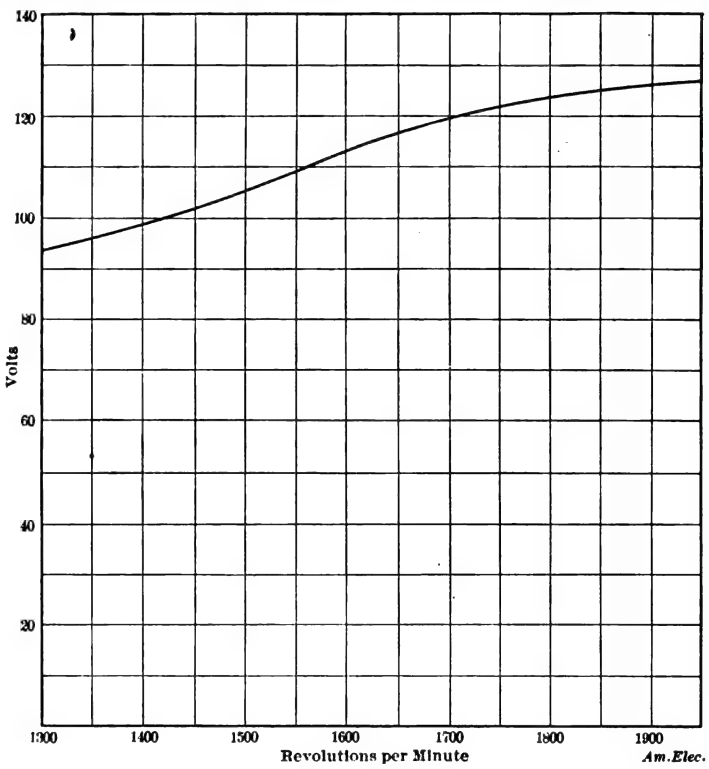

FIG. 2.—SPEED CURVE.

possible with all the resistance out of the rheostat and the current carefully read; and this current must be kept constant throughout the test. This is done by throwing in resistance as the speed increases. The following are actual data:

TABLE I.

SPEED CHARACTERISTIC CONSTANT FIELD.

Volts.	Speed R.P.M.	Volts.	Speed R.P.M.	Volts.	Speed R.P.M.
94.5	1346	102	1450	118.5	1670
95	1361	103	1486	120	1712
95.6	1370	105.5	1508	122	1768
96.5	1384	107.5	1537	124.5	1847
98	1399	110	1575	127	1952
99	1409	113	1614	......	......

From these readings the curve shown in Fig. 2 was platted. It is to be noticed that this speed characteristic was taken with a field practically constant, the speed alone being varied. The curve departs from a straight line at 1700 r. p. m. At this point the eddy currents in the armature core become strong enough to react on the field and weaken it perceptibly. This particula machine cannot be run economically beyond

1700 r. p. m. To run at a higher speed, the core should be built up with better iron and finer laminations.

Another speed characteristic, though somewhat more complex, is none the less instructive. It may be called the speed characteristic with variable exciting current. It is designed to exhibit the variations in voltage as

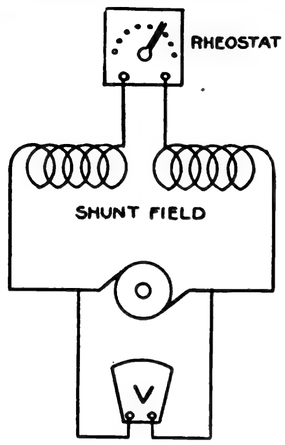

FIG. 3.

the speed changes. It can be seen that this is a curve for the actual running condition of the dynamo. The connections for the curve are shown in Fig. 3, and need no explanation other than that the rheostat employed is the usual regulating rheostat of the dynamo. The rheostat may be set at

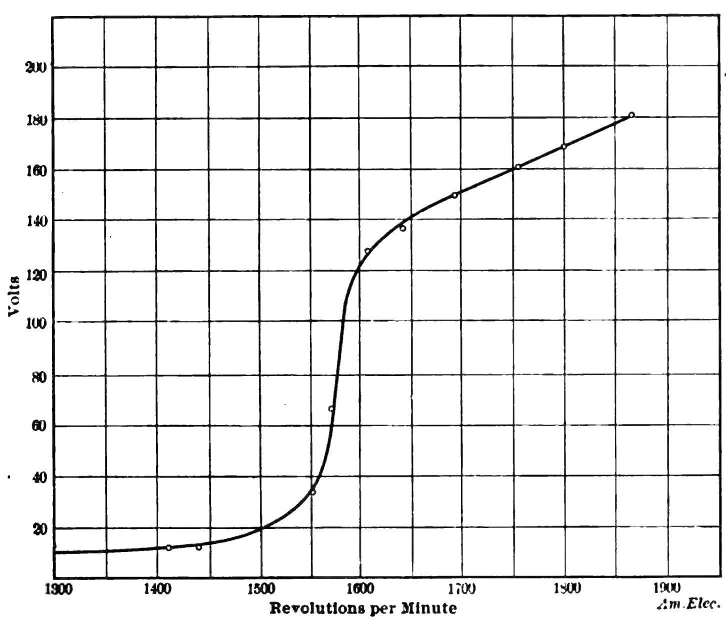

FIG. 4.—SPEED CURVE.

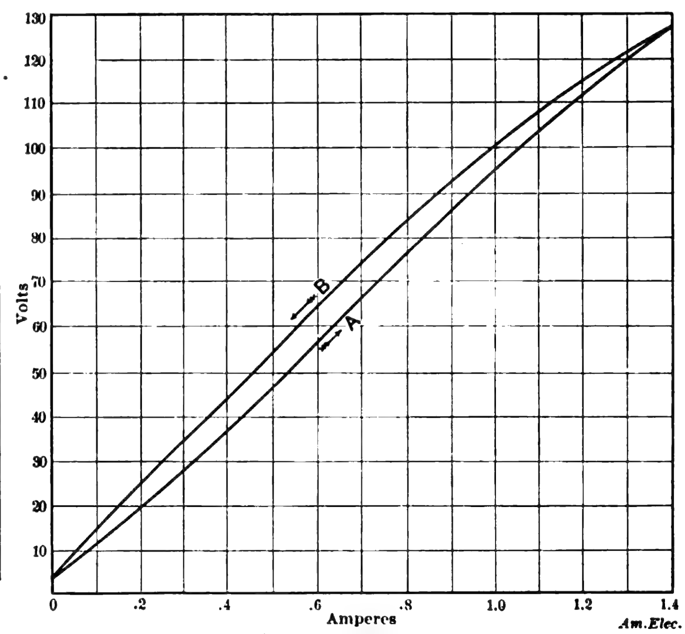

FIG. 6.—MAGNETIC CURVE.

the point which will allow the usual shunt current to pass under normal speed. The speed, as is seen from the data, is varied over very wide limits, while the rheostat

TABLE II.

SPEED CHARACTERISTIC VARIABLE FIELD.

Volts.	R.P.M.	Volts.	R.P.M.	Volts.	R.P.M.
10	1300	34	1550	157	1722
11	1338	67.5	1570	161	1756
12	1410	93	1584	170	1800
14.6	1440	128	1606	177	1838
16	1444	138	1640	181	1859

once set for the test is not varied. The following data were obtained from such a test:

These results were plotted to form the curve shown in Fig. 4. The curve has been purposely exaggerated by placing considerable resistance in the shunt circuit. It is noticeable that at 1500 r. p. m. the E. M. F. increases rapidly, and from 1650 r. p. m. to the end of the test the E. M. F. increases uniformly. The curve indicates that the dynamo should be run at either 1400 r. p. m. or 1750 r. p. m. in order to regulate properly. Between these speeds the field is too sensitive, for the slightest change in speed would cause an enormous change in the E. M. F. The general argument for the curve is that the current in the fields changes directly with the voltage, and the voltage changes with any variation of the field.

One of the most instructive curves that can be taken from a dynamo is called the magnetization characteristic. It is obtained by separately exciting the field through the shunt, or shunt and series coils, as explained above. The connections are shown in Fig. 5, where *A* is a suitable ammeter for measuring low currents, and *R* is a resistance in series for controlling the exciting current. The dynamo must be run at a constant speed throughout the test, and the current increased by regular additions until the maximum exciting current which the coils will carry is reached; then the current is decreased in the same manner until it has again reached the value at which the test was begun. The essential for this test is that the exciting current must be regularly increased or decreased, and in no case should

TABLE III.

MAGNETIZATION CHARACTERISTIC CONSTANT SPEED, 1380 R. P. M.

Volts	Amp.	Volts	Amp.	Volts	Amp.	Volts	Amp
3	0	67.8	.71	109.1	1.11	21.5	00
14.5	.165	76	.795	104	1.05	......	......
20.7	.225	82	.85	90	.855	......	......
25.5	.227	89	.94	76	.72	......	......
30	.32	95.2	1.005	65.9	.62	......	......
35.2	.37	100.5	1.06	58	.54	......	......
41	.425	106	1.125	50	.45	......	......
45.4	.47	111	1.19	45	.405	......	......
49.8	.535	124	1.355	34.6	.30	......	......
55.3	.575	127.2	1.4	29.5	.25	......	......
60	.625	118.5	1.24	20.1	.105	......	......

the circuit be opened. The dynamo must be on open external circuit, and a voltmeter connected to the brushes. The actual data from such a test are given in Table III, while the curve plotted from this is shown in Fig. 6:

The lower half of the curve, *A*, shows the relative strengths of the field when the exciting current was increased; the upper half, *B*, the values when the exciting cur-

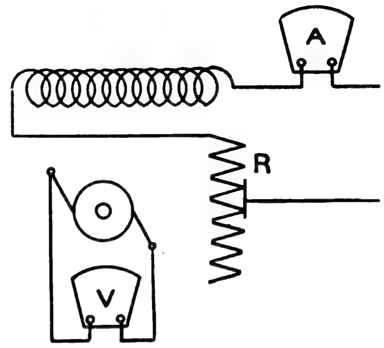

FIG. 5.

rent was decreased. This curve clearly shows the magnetic quality of the iron in the field. The reason that the portion, *B*, is higher than *A* is that the iron possessed a "set" or "lag" behind the inducing current. If the iron had entirely responded to the magnetizing current, *A* would have been higher, and *B* lower, and the two would have coincided into one line. This behavior of the iron is due to an action called *hysteresis*, a term whose explanation will be attempted in a subsequent article. The extent of the area included between *A* and *B* is significant, and is a measure of the exciting power lost in simply heating the iron due to the friction of changing the positions of the constituent molecules. It is noticeable that when the exciting current exceeds .8 ampere, the voltage does not increase proportionally to the exciting current. This indicates that, for the most economical action of the dynamo, it should be operated with a magnetic field not greatly exceeding that produced by .8 ampere. With poorer iron in the field, this hysteresis area between *A* and *B* would be increased, while with better iron it would be lessened.

NOTES.

The Underground Trolley in New York.—The Metropolitan Street Railway Company has redeemed its promise to extend electric traction in New York, by recently awarding contracts to the General Electric Company for equipping the Sixth, Eighth and Amsterdam Avenue lines on the West Side, the Fourth and Madison Avenue lines on the East Side, and the Fifty-ninth Street crosstown line, with the underground trolley system now in operation on Lenox Avenue. The street construction will be begun as soon as the weather becomes sufficiently settled, and it is expected that the lines will be in operation next fall. The newly acquired Second Avenue line will also be equipped with electricity.

An Electrical Mercantile Agency.—A significant indication of the extent of the electrical field is afforded by the recent establishment in New York of a mercantile agency whose scope is limited to the electrical industry alone, standing in the same relation to it that Dun and Bradstreet do to general business. It is somewhat startling to discover, by reference to the credit book of the new agency, that there are between 12,000 and 15,000 concerns of all kinds in the United States that are in one way or another within the electrical field. Owing to the manner in which the several large electrical companies have monopolized public attention, it requires a reminder like this to realize how great are the ramifications of the industry.

The Pacinotti Ring.—The toothed form of armature used in the famous Pacinotti model which first demonstrated the principles of the modern dynamo and motor, is often referred to as if the teeth had been considered by the Italian professor an integral part of his great invention. We are informed by an Italian electrical engineer acquainted with the circumstances attending the construction of the original machine, that this is not the case, a toothed ring having been used merely because it happened to be the only form of ring obtainable at the moment. The eccentric professor, we learn from the same informant, is apt to be irritated if, in conversation with him, the teeth of the armature are referred to as an intentional feature of the model.

The Telephone Situation.—In a paper read before the Chicago Electrical Association, Mr. W. Clyde Jones thoroughly discussed the telephone situation with respect both to the telephone itself and the switchboard. The conclusion arrived at is that there are now in existence no patents which prevent the installation and operation of an exchange in its entirety, and that the only patent in any wise controlling in its scope is the Berliner patent, purporting to cover every form of microphone transmitter. While Mr. Jones considers that it is of the highest importance to the public at large to possess the microphone transmitter in the operation of exchanges, he believes that it is by no wise essential, and that it is safe to say should the Berliner patent be sustained, that inventive genius will improve the magneto-telephone or the liquid-electrode transmitter to the degree which will place in the hands of the public a thoroughly successful transmitter.

The Chicago Electrical Association.—The winter and spring announcement of the Chicago Electrical Association presents a programme of papers which should still further add to its already enviable prestige. The two papers for February are on "The Telephone Situation", by W. Clyde Jones, and "Vacuum Tube Lighting", by M. A. Edson. At the bi-monthly spring sessions the following papers will be read: "Electrical Resonance", by Kempster B. Miller; "Cable Testing", by Geo. D. Hale; "Requirements of High Speed and Heavy Electric Traction", by Hayward Cochrane and E. J. Swartout; "Arc Lighting in America and Europe," by C. Wiler; "Direct Current Transformer," by C. H. Thordarson. The present officers of the Association are as follows: President, S. G. McMeen; vice-president, F. S. Hickok; treasurer, E. J. Jenness; secretary, J. R. Cravath; directors, W. Clyde Jones, G. W. Knox and Kempster B. Miller.

Ship Lighting.—In the current number of *Cassiers Magazine* Mr. E. G. Bernard in an article on "Electric Ship Lighting" relates his experience in installing the second man-of-war lighting plant of the United States Navy—that on the *Omaha*. The circuit consisted of lead-encased cables, and Mr. Bernard writes that he has a vivid recollection of the difficulties met in boring several hundred ¼ in. and ½ in. holes for the port and starboard mains, through about 8 ins. of gnarled oak almost as difficult to pierce as a tough metal. It is perhaps needless to say, he adds, that the cost of labor and tools for this part of the work formed no small item in the total cost of installation. Mr. Bernard states that lead-incased conductors were finally discarded for ship work, except in especial cases, for the reason that the protection which the lead covering was supposed to give from injury to the insulation, and from the entrance of moisture, was found to be illusory. Dents caused short circuiting on the sheaths of the conductors, and punctures, by permitting the entrance of moisture, led to bad grounds and to short circuits.

The Magnetic Club.—The Magnetic Club held its winter meeting Feb. 3, at the rooms of the Transportation Club, Hotel Manhattan, New York. The occasion was a most enjoyable one, and some 150 members and their friends sat down to an excellent menu. The club was started some six or seven years ago, and at these meetings, which are held four times a year, there is always a good attendance. The club was started originally by men in the telegraph field, but its members now include many in the other branches of the electrical business. The special feature of this meeting was the inauguration of the new president, Mr. E. H. Johnson, under whose administration the club is bound to take on new life and enthusiasm. After dinner the president made a happy address, which was received with much applause. Letters of regret and congratulation were read from many who were not able to be present. A very notable feature of the meeting was in its being made the occasion of celebrating the recent passing of the bill by Congress reorganizing the service of the United States Military Telegraph Corps for its services during the late Civil War. Another pleasant event was the presentation to Secretary Geo. Fagan, of a handsome magnet-shaped diamond pin. The meeting closed with an excellent musical programme which was thoroughly enjoyed by all.

An Automatic Telephone System.—There is now on exhibition in New York an automatic telephone system, which involves radical departures from old methods, each subscriber being enabled by it to call, and to connect himself with, any other of, say, 100 subscribers on his own section, and this in the most simple manner, so far as the manipulations of the subscribers are concerned. "Central" is only utilized to make connections from one section to another, thus, it is claimed, reducing Central Office expenses upwards of 80 per cent. The manner of erecting wires for this system will necessarily effect a great saving in the expense of maintenance, as there are but ten wires where 200 are now employed. In small towns no Central station would be necessary, each subscriber being able to secretly call and communicate with any other, and this with only about 5 per cent of the number of wires usually employed. The instrument is but little larger than the ordinary "Bell" instrument, and contains simple mechanism effecting individual calling and automatic selection of wires, so that only the individual desired is called, and no one can interrupt correspondents while telephoning. Calling and telephoning are distinct, and neither is limited in operation by the other. If such a system realizes the promise it contains, a new era in telephony is foreshadowed, particularly with respect to small towns.

High Voltage Transmission.—A San Francisco correspondent takes issue with respect to certain statements printed in our January number in a note entitled "High Voltage Transmission." "Your correspondent's statements concerning the transmission of power in San Francisco," he says, "are entirely misleading as regards the successful working of high voltage, and the method used. Following is a brief description of the service up to about a year ago, since which time the constant-current system has been gradually abandoned, and the constant-current motors replaced by constant-potential motors connected to the underground service. As regards the C. C. service, I wish to say that one large dynamo was not used (as stated in the note referred to), but small units were run in series (No. 8 Brush machines connected to deliver a 20-ampere current), two to each circuit, which, at full load, gave about 3000 volts per circuit. The 20-ampere service consisted of three such sets, and whenever any of the sets had a large fluctuating load, as would sometimes occur in operating hoisting motors, etc., one of the other sets would be switched in series with it, consequently doubling the voltage to about 6000 volts per circuit; when the occasion demanded, the entire three sets (six machines) were run in series, giving 9000 (approx.) During the past eight years of this service, absolutely no trouble was experienced on the score of high voltage, and regulation was facilitated by such combinations."

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The Earth as a Conductor.

One of the fallacies handed down from days that are prehistoric with respect to modern electricity, is that the earth is an excellent conductor. This error was propogated in the earlier books on electricity, and even at the present time is very widely disseminated. Dr. Bell has, therefore, done a real service in showing up its falsity, and his article in another column on this subject will be found one of much interest. He demonstrates that, instead of the conductivity of the earth being almost perfect, it is actually so meagre, as to be practically insignificant, except in the case of very high voltages or very minute currents; and that, while the earth return may continue to be advantageously used in telegraphic work, it is useless, under existing conditions, for power service, and harmful when forming part of an electric railway circuit.

Dynamo Characteristics.

Though much has been written on the dynamo characteristtic, it yet remains largely a thing of text-books to the average electrician. On another page Prof. Stine shows that, far from being merely useful to the theorist or designer, the characteristic really occupies the same practical relation to the dynamo that the indicator does to the steam engine. Moreover, instead of requiring for its determination the use of special instruments and refined experimental skill, it is shown that anyone in charge of a dynamo who possesses, or can procure the use of, a good voltmeter and ammeter, may correctly lay down the several curves of his machine without any other knowledge than may be obtained from the simple directions given in the article. Aside from the practical value of curves thus obtained, their determination for a machine will be exceedingly instructive by leading to an appreciation of the real nature of what may otherwise be looked upon in the light of abstractions.

Rotary Converters.

With the electrical transmission of power the rotory converter came to the front, and to-day occupies an important position among electrical apparatus. Instead of being something complicated and mysterious, as seems to be supposed by many, it is simply, as pointed out by Mr. Berg in another column, a continuous-current generator to which rings are added, the latter being connected each to a single point of the continuous-current winding. The alternating current delivered to the machine drives the armature at a speed synchronous with its alternations, the effect of which synchronism is to cause the alternating current to have the same relation in the armature winding with respect to the commutator, as the alternating currents generated in the same machine would have should it be driven simply as a continuous-current generator. Consequently, the current which passes in at rings alternating is delivered at the commutator continuous. The energy consumed in running the converter merely corresponds to that required for the same machine running free at the same rate of speed; in other words, were there no copper and iron losses, no energy would be taken to run the machine.

Efficiency of Incandescent Lamps.

The paper read by Mr. F. S. Terry at the Milwaukee convention brought out clearly an important point which is often neglected by those who advocate the use of high-efficiency lamps—the fact that any central station manager using a good low-efficiency lamp has merely to raise his voltage in order to bring about the condition of high-efficiency working which he is told is so desirable. In other words, a low-efficiency lamp at one voltage is a high-efficiency lamp at an increased voltage. This thoroughly disposes of the somewhat ludicrous charge which has publicly been made, that the profits of central stations are kept down by the refusal of lamp manufacturers to supply 2-or 2½-watt lamps. If a central station manager wishes to try the experiment of using so-called high-efficiency lamps, the matter lies entirely in his own power—he need only raise his voltage; it would, however, be advisable before doing, so for him to see that his stock of new lamps is in condition to meet a sudden and excessive demand. With variations in voltage on central station circuits that not infrequently reach ten per cent., a glance at any table of data of lamp tests will make evident the folly under such conditions of attempting to use high efficiency lamps. Such an examination will also sustain the statement made by Mr. Terry, that in most cases a 3½-watt lamp is the best for the average central station.

Municipal Ownership.

The discussion at the recent convention of the Northwestern Electrical Association on the subject of municipal ownership of electric lighting plants, showed a most rational appreciation of the real situation. Those taking part in the discussion realized what should have been understood more clearly long ago—the fact that the only method whereby to successfully meet attacks upon private ownership of town and city lighting plants, is to show what is true beyond a

shadow of doubt in almost every case—that municipal ownership will not pay. Pressure brought to bear on manufacturers to prevent their selling the necessary plant to municipalities is futile, for if all of the present manufacturers should bind themselves not to do so, others making a specialty of municipal plants would come forward. Economic and ethical argument will have little effect, for to those who can understand the considerations urged, their weight will be weakened on account of the *ex-parte* source, while they will have no effect whatever on the great multitude of voters. Actual figures, however, would be convincing to all, even to those who accept municipal ownership as a doctrine of faith. As we have pointed out before in these columns, such figures with respect to existing municipal plants can only be obtained by personal investigation made on the spot by experts. This fact is beginning to be more generally realized in view of the failure of the many attempts that have been made to gather such statistics by correspondence or reference to municipal reports.

Alternating-Current Wiring.

Elsewhere will be found two articles on the principles applying in the calculation of alternating-current wiring—one by Mr. Geo. T. Hanchett, which includes curves by means of which the size of conductors may be determined for a given distance apart and frequency, and another in which the principles of inductance are developed with respect to parallel conductors carrying alternating currents. An interesting point brought out in both articles is that the inductive drop is not increased by increase in size of wire, as is usually implied. In fact, the component of the inductive drop into which the size of wire enters, actually decreases as the diameter is increased. Inductive drop is larger with large wires for the reason that in all practical cases the current increases with the size of wire; therefore, with large wires there are large currents and consequently large inductive drops.

In fact, for all practical purpose, the inductive drop on a given line may be considered to depend upon the current alone, so preponderating is that factor. Bearing this in mind, the reason is plain why the so-called impedance factor, or the ratio between simple ohmic drop and inductive drop, increases so greatly as the size of the wire increases. If, for instance, the diameter of a wire is doubled, its ohmic resistance is quartered, while, on the other hand the inductive drop is comparatively slightly decreased. Consequently, the combined resistance and inductive drops or the total drop, decreases at a much less rate than the ohmic drop, from which it follows that the ratio of the ohmic resistance to the total drop is largely increased by increasing the size of wire.

The numerical example elsewhere given will render it plain that the effects of inductive drop can be neutralized by increasing the size of the conductor only within very narrow limits. In fact, for very large currents the total drop might, in a given circuit, remain very large if the conductors were entirely devoid of ohmic resistance. For example, with a conductor an inch in diameter, the inductive drop would so outweigh the resistance drop on account of the large current such a wire would carry, that the latter component would cut a very small figure in the total drop, and consequently, increasing the size of the conductor a number of times would not notably affect the original drop. The conclusion to be drawn from these considerations is that where, in interior wiring, large alternating currents are involved, multiple circuits should be used. By employing two or more pairs of small conductors of a combined resistance equivalent to that of the larger pair, the inductive drop component will be reduced to that of the smaller conductors, and may thus be so small as to be negligible; this, therefore, reduces the drop to that due merely to resistance, upon which basis alone the conductors may then be calculated.

Efficiency of the Steam Engine.

On another page will be found an article on the efficiency of different types of steam engines, the conclusions of which may be rather startling to those who have mistakenly put their faith in the statement so frequently made, that the steam engine is an incorrigibly inefficient machine. It will be seen that there are engines which work the steam supplied at an efficiency as high as 68 per cent., the basis of comparison being a perfect engine—that is, an engine utilizing all of the heat in the steam supplied which nature renders available for transformation into mechanical work under given conditions as to initial and final temperature. As with the highest pressures now carried, less than one-third of the amount of the heat contained in steam is available for transformation into work, such an engine would be credited by the calamity writers on the steam engine with an efficiency of less than 23 per cent.

The absurdity of basing the efficiency of the steam engine on the ratio of the range of working temperature to the absolute temperature of admission, was pointed out in a previous article. It may not be amiss, however, to here repeat, that such a basis involves an infinite number of expansions and the attainment in working of the absolute zero of temperature—the former, in turn, implying a cylinder of infinite stroke whose piston would have to travel miles to develop a fraction of a horse-hower. To put the matter in another way, after expanding steam in a perfect engine down to the lowest vacuum used in practice, and in doing so utilizing all of the heat available to that point for transformation into work or, say, 23 per cent., the remaining 77 per cent. can only be utilized by carrying on the expansion to infinity. During this subsequent period, a piston would have behind it a pressure whose maximum would only be the pressure of release, dropping rapidly to an infinitesimal amount which, however, being exerted over planetary distances, would, in the course to infinity, aggregate the difference between 100 and 23 per cent. or 77 per cent. of the work in the heat of admission, which heat otherwise passes off in the exhaust.

As stated before, the comparisons in the article are based upon a perfect engine, or one working in a Carnot cycle. In practice, however, the conditions which this involves can never be attained, and therefore the efficiencies calculated are lower than if based upon the most perfect conditions applying in actual working. In another article efficiencies will, therefore, be calculated on the basis of the heat in steam available for transformation into work down to the point of release under conditions of expansion that apply in the actual steam engine. The efficiencies calculated on the first basis, nevertheless, enable a most important conclusion to be arrived at, which is that future improvements in steam working lie in the direction of improving the working efficiency of the steam rather than in the use of higher pressure. It is true that thus far there has been an intrinsic increase in efficiency for each increase in the number of cylinders in which expansion is carried out. On the other hand, before carrying further the complication of multiple-expansion cylinders, which involve corresponding increase of pressures with accompanying disadvantages, it would seem more rational to halt in that course for awhile and turn attention toward the direction indicated. Very fortunately, there is no uncertainty as to the measures to be taken, for superheating offers the desired promise, and the first step in this direction is toward the use of live steam reheaters in the receivers of multiple-expansion engines.

DESIGNS FOR SMALL MOTORS. I.

ONE-SIXTH HP MOTOR WITH DRUM ARMATURE.

BY CECIL P. POOLE.

In preparing the series of articles of which this is the first, it has been assumed that anyone who is sufficiently interested in the subject to undertake the construction of a motor or dynamo will be sufficiently familiar with electro-mechanics to exercise individual judgment in the matter of fitting the various parts, and also in the design and construction of journal boxes, brush holders, terminal blocks and such other parts as are not of vital importance in the electrical design of the machines. Detailed descriptions of these parts will, therefore, not be given; the reader may easily inform himself concerning these, if necessary, by inspecting a finished machine of almost any type, or by reference to any good text-book.

The accompanying sketches are intended to serve as working drawings in the construction of a ⅙-HP motor, for operation upon a 110-volt continuous-current circuit. In Fig. 1, *M* is the field magnet, consisting of a bar of wrought iron three inches wide and one inch thick, bent into the shape shown; the inner surface of each limb is machined smooth a distance of three inches, forming shallow mortises to receive the pole-pieces, *P P*, which are secured by ¼-in. cap screws passing through the magnet limbs. The pole-pieces, *P P*, are of gray cast iron, and should be finished on all sides to remove the scale as well as to improve the appearance of the completed machine. The magnet, *M*, might be made to look neater by touching up its sides on a coarse emery wheel; it should be well annealed after bending and finishing.

Two holes, *h*, *h*, are bored through the pole-pieces after these are fitted to the magnet, but *before the armature chamber is bored out*. These holes are 17/64 in. diameter, and they must be 3¾ ins. apart, center to center, and equidistant from the center of the armature chamber; if the magnet limbs conform strictly to the measurement given from face to face of the finished part of the limbs, the centers of the holes, *h*, *h*, will each be 5/16 in. from the joint between the magnet and the pole-pieces. In these holes are to be inserted ¼-in. iron or steel rods 7¼ ins. long, threaded at each end a distance of ⅜ in. Fig. 2, which gives a plan view of the magnet and the journal yokes, *Y*, *Y*, shows the function of these rods; they support the yokes and carry distance-pieces, *c*, *c*, *d*, *d*, made of brass tubing just large enough to slip over the rods, and having ⅛-in. walls. The pieces, *c*, *c*, are 1⅜ ins. long, and *d*, *d*, are 2⅛ ins. long. The yokes are held in place by brass nuts, not shown in Fig. 2.

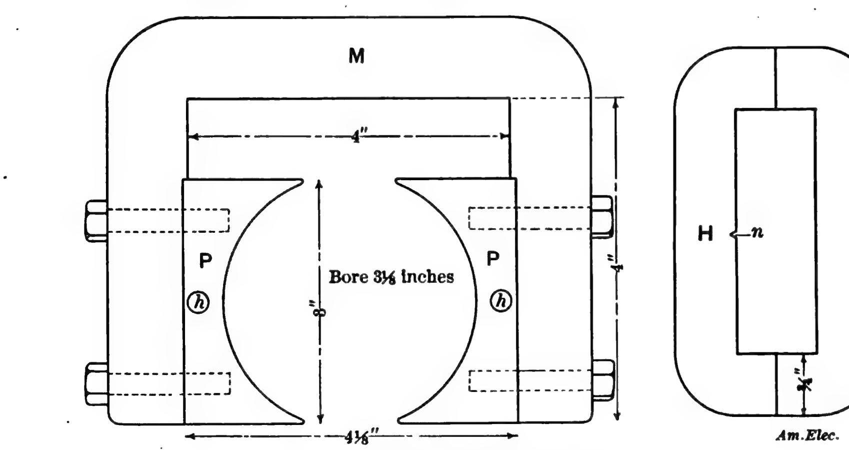


FIG. 1.—FIELD FRAME.

The journal yokes, *Y*, *Y*, are alike. They are of cast brass, ⅛ in. thick, with a stiffening rib ⅛ in. thick, on each side of the journal box. The inner end of one box should be trued up to receive the brush arm or quadrant. The yokes may be much more easily and accurately fitted if a steel template is used. This may be cheaply provided by taking a piece of flat steel, 1 in. wide and 4½ ins. long, scribing a straight line approximately down the center, and drilling three holes as shown by *T*, Fig. 2, the center one 11/16 in. and the others ¼ in. in diameter. After the box is bored, mount it on a mandrel and turn down the inner end to fit the center hole in the template *T*, and at the same time face up the ends of the yoke where they are to touch the distance-pieces; put the template on the end of the box and scribe the positions of the ¼ in. holes on the ends of the yoke. This template should also be used to fix the distance apart of the holes, *h*, *h* (Fig. 1). The boxes are bored out 5/16 in. in diameter and fitted with bushings of ¼ in. bore and 1 in. long; oil grooves should be cut at each end of the box and provision made for taking out the oil. Oil cups may be used to feed the bearings.

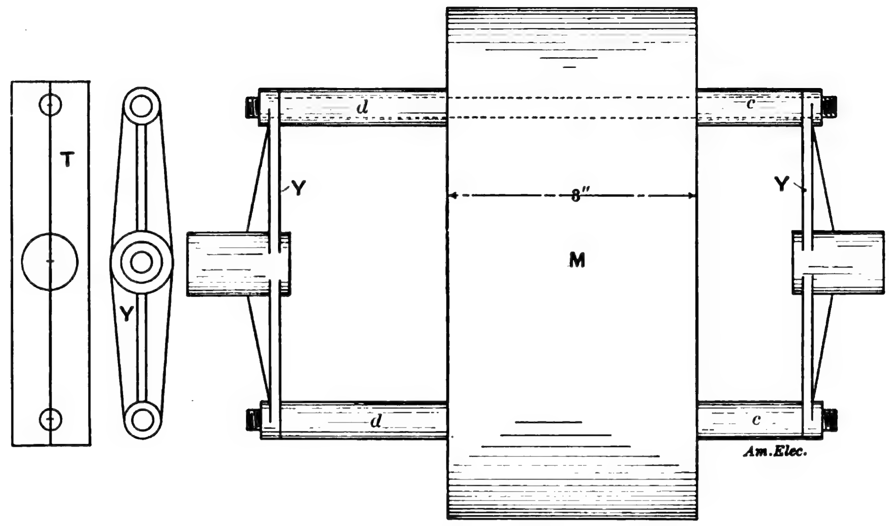


FIG. 2.—JOURNAL YOKES.

After the yokes are fitted the frame may be centered in a lathe as follows, for boring out the pole-pieces. Take a piece of ½ in. steel rod 11 ins. long, and make the shaft, *S* (Fig. 3); the distance from *e* to *g* is 3¼ ins., and the diameter there is ¼ in.; from *g* to *i* is 3 11/16 ins., and the diameter ⅜ in.; from *i* to *j* is 1 1/16 ins., and the diameter ½ in.; from *j* to *k* is 3 ins., and the diameter is ¼ in. Turn the ends of the shaft down to a point, like that of a lathe center; put it in the boxes, bolt the yokes in place, and then put the frame on the lathe carriage, adjusting it until the sharp ends of the shaft are in exact line with the lathe centers. Bolt the motor down in this position, remove the yokes and shaft, and bore out the pole-pieces. The ends of the shaft should afterwards be squared off, care being taken to cut exactly ½ in. off each end, leaving the shaft 10 ins. long.

The armature (Fig. 3) is built up of iron disks 3 ins. in diameter and not more than 1/32 in. thick; there are twelve slots, each 5/16 in. wide and 7/16 in. deep. These may be punched in each disk separately, if a stamping press is available, or they may be milled after the disks are assembled on the shaft. If the slots are milled the disks should be taken off the shaft afterwards and the burrs dressed off, care being taken to reassemble them exactly as they were when the slots were milled; this may be accomplished by taking a very slight cut with a metal saw along the top of one tooth, using the mark as a guide to get the proper slots together. In order to get them in exact alignment, a rectangular bar of metal should be made to fit snugly in one slot before taking the disks off; when they are put back this bar is inserted in the slot to which it was fitted, and the nut is set up hard. End plates, *w w*, of brass, 2 ins. in diameter and 5/16 in. thick, serve to prevent the end disks from buckling when they are compressed. A nut (not shown) fitted to the thread which begins at *g* on the shaft, serves to clamp the disks, which are held at the other end by the shoulder, *i*; no key is necessary to prevent the disks from turning on the shaft in so small a machine, but it is essential that they should be clamped as

tightly as a fairly strong man can clamp them, using a six-inch wrench on the nut. The shaft may be held in a pipe vise between *i* and *j* when setting up the nut; the nut should be made of very hard bronze metal in preference to steel, as the latter attracts magnetic lines of force and is liable to heat.

The commutator may be made as shown in the sketch, or according to any other modern plan, a number of which were described in the AMERICAN ELECTRICIAN, of July, 1896. The only essential features are the space along the shaft which must not exceed ¾ in., the width of face, which should not be less than ½ in., and the number of segments, which must be 12. The commutator here shown is intended to be secured to the shaft by a small steel set-screw through the hub or boss at the front; the end of this hub, *f*, must be 1¼ ins. from the end of the shaft. Extreme care must be taken to insulate the segments from the shell as well as from each other; mica is the only reliable material for this purpose. Carbon brushes ½ in. wide and ¼ in. thick should be used.

The armature core is next prepared for winding. Cut four disks of heavy drilling (so-called twilled muslin), 2¼ ins. in diameter, with a ⅜ in. hole in the center; varnish the ends of the armature core with shellac and varnish two of the cloth disks, each on one side; thread them on the shaft, one at each end, with the varnished sides next to the core, and press them tightly on the core. While the varnish is hardening, cut 24 pieces of drilling the shape of *t* (Fig. 3); cut two slits, ¼ in. long, in each end, 7/16 in. from each side and 5/16 in. from each other; varnish the strips on one side, and when nearly dry bend them along the dotted lines so as to form troughs, with the varnish inside the trough. Varnish the outside of each trough and the walls of the slots in the core; put two troughs in each slot and turn the flaps, *u*, *v*, *w*, flat against the end of the core, applying enough fresh shellac to hold them down. Then put on the two remaining end disks of cloth, first varnishing the sides next to the armature; after they are in place, varnish the outsides and put the core in an oven to bake, being careful that the oven is not hot enough to scorch the cloth. A temperature of 130 degs. F. is sufficient. After baking, tape the shaft thoroughly from *i* to *j* and from the other end of the core to where the commutator will come.

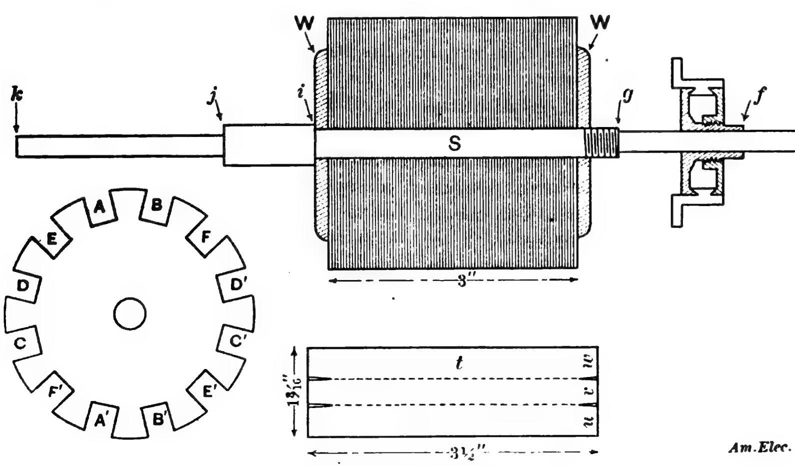


FIG. 3.—ARMATURE COIL.

The coils consist of 48 turns of No. 24 double cotton covered wire each, wound 8 turns wide and 6 deep in the slots, but spread out as flat as possible across the heads. Wind coil No. 1 in slots, *A A′*; coil No. 2 in *B B′*; No. 3 in *C′ C*; No. 4 in *D D′*; No. 5 in *E E′*, and No. 6 in *F F′*. Coil No. 7 goes in *A′ A*, on top of coil No. 1, but beginning on the opposite side of the core, as indicated by the lettering; No. 8 in *B′ B*; No. 9 in *C′ C*; No. 10 in *D′ D*; No. 11 in *E′ E*, and No. 12 in *F′ F*. After winding each coil, bring the finishing end across to the slot where the starting end enters, and twist the two lightly together. When all the coils are on, untwist the coil ends and twist the last end of each coil to the starting end of the coil in the slot next to it *on the right;* these twisted ends go each to a commutator segment, in regular order.

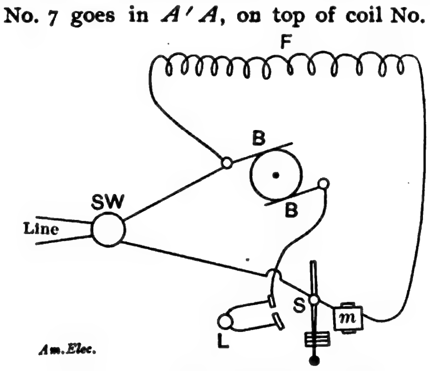


FIG. 5.—MOTOR CONNECTIONS.

The field magnet is easily made ready to wind by taping the horizontal part of the magnet, two layers deep, with varnished muslin and putting on two fibre heads. One of these heads is shown by *H* (Fig. 1). It is in two pieces, the seams being at the ends, and is cut from ⅛ in. sheet fibre. The two halves may be clamped together on the core by means of a small brass wire drawn around the outer edge, laying in a shallow groove, the ends being twisted and cut close. The pole pieces should be removed before taping and putting on the heads, to facilitate these operations as well as the winding of the coil. One fibre head has a notch, *n*, half way of its inner long side, to enter the field wire. The coil consists of No. 28 wire, B. & S. gauge, 34 layers deep and 170 turns long, making 5780 turns in all. The field winding is connected in shunt to the brushes, and it would be a good plan to provide a starting switch and resistance lamp connected up as shown diagrammatically by Fig. 5, where *F* is the field coil, *B B* the brushes, *L* a 32-CP, 100-volt, incandescent lamp, *S* the starting switch, *M* a magnet and *S W* a double-pole snap switch. This arrangement could be mounted on the base of the motor. Fig. 4 shows the complete motor on a wooden base, *Q*, without the pulley; the latter may be any diameter between 1½ ins. and 2½ ins., with a 1-in. crown face or ½-in. grooved face. The motor is secured to the base by flat head machine screws from below, entering the ends of the wrought iron and countersunk in the under side of the wood. This machine will stand a momentary overload of 100 per cent. and will work up to ¼ HP for half an hour at a time.

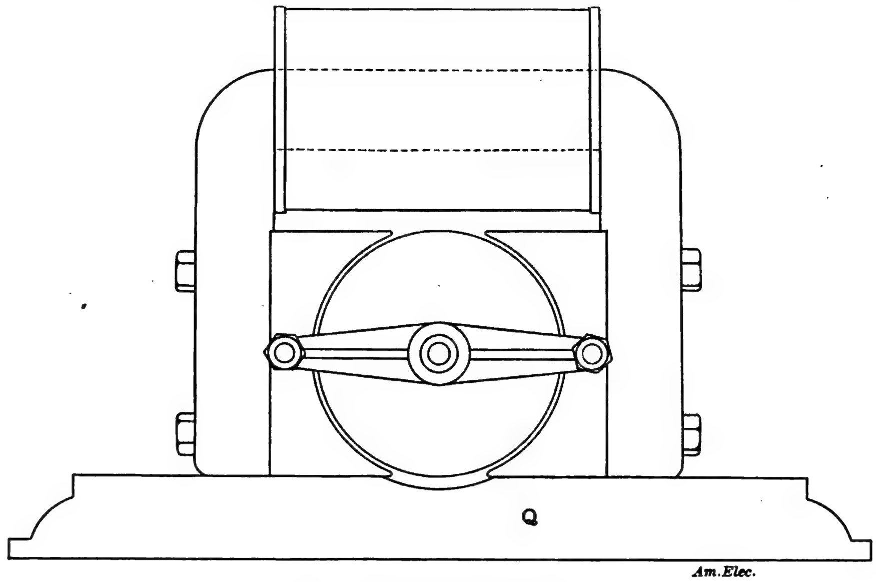


FIG. 4.—COMPLETED MOTOR.

Resistance of Insulators.

The electrical resistance of all insulating materials decreases rapidly with increase of temperature. That of gutta percha, for example is twenty times less at 75 degs. than at 32 degs. F., while the resistance of glass is 120 times less at 140 degs. than at 68 degs. F.

AMERICAN TELEPHONE PRACTICE.

BATTERY TRANSMITTERS.

BY KEMPSTER B. MILLER.

Among the earlier forms of the granular transmitter is a very efficient one designed by Emile Berliner, and called the "Berliner Universal." In this the diaphragm, *D* (Fig. 1), is of carbon, and is mounted horizontally in a case formed of the two pieces, *A* and *B*, of hard rubber, a brass ring, *R*, being clamped above it to insure good electrical contact. Secured to the enlarged head, *f*, of the screw, *S*, mounted on the block, *B*, is a cylindrical block of carbon, *C*, on the lower face of which are turned several concentric V-shaped grooves. The points formed between these grooves almost touch the diaphragm. The finely divided carbon, *c*, rests on the diaphragm, and is confined in the space between it and the carbon block by a felt ring, *F*, which surrounds the latter and bears lightly against the diaphragm. To the center of the back plate a soft rubber tube, *r*, is fixed which is of sufficient length to make contact with the diaphragm, its function being that of a damper to the vibrations of the

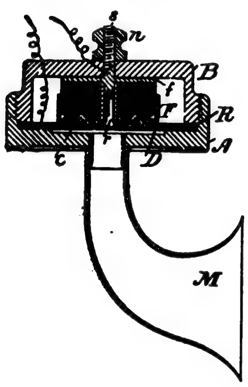


FIG. 1.—BERLINER "UNIVERSAL" TRANSMITTER.

diaphragm. The mouth-piece, *M*, is so curved as to conduct the sound waves against the center of the diaphragm. This transmitter was used to a considerable extent by the American Bell Telephone Company, and has only recently been replaced for long distance work by the White transmitter.

The White, or "solid back" transmitter as it is called, is shown in Fig. 2, the separate parts of the working portion of the instrument being shown in the small cut at the bottom of this figure. This instrument has proven remarkably successful in practice, it being able to stand a very heavy current without undue heating. Besides this, the tendency of the granules to settle down in a compact mass, commonly called "packing," is greatly diminished.

F is the front piece of the transmitter case, and is held, as shown, in the hollow shell, *C*, the two pieces forming a complete metallic casing for the working parts of the instrument. The sound-receiving diaphragm, *D*, is encased in a soft rubber ring, *e*, and is held in place by two damping springs, *ff*, as in the Blake transmitter. *W* is a heavy metallic block hollowed out, as shown, to form a casing for the electrodes. The inner circumferential walls of this block are lined with a strip of paper, *i*. This block is mounted, as shown, on a supporting rod, *P*, secured at its end to the outer casing of the transmitter. The back electrode, *B*, of carbon is secured to the face of the metallic piece, *A*, which is screw-threaded into the block, *W*. *E* is the front electrode, also of carbon, carried on the face of the metallic piece, *b*. On the enlarged screw-threaded portion, *p*, of the piece, *b*, is slipped a mica washer, *m*, held in place by the nut, *u*. This washer is of sufficient diameter to completely cover the cavity in the block, *W*, when the electrode is in place. After the required amount of granular carbon has been put into the cavity and the front electrode put in position the cap, *c*, is screwed in its place on the block, *W*, as shown, and binds the mica washer, *m*, firmly against the face of the block, *B*, thus confining the granules in their place. The electrodes are of somewhat less diameter than the paper-lined interior of the block, *W*, so that there is a considerable space around the periphery of the former, which is filled with carbon granules. This prevents the binding of the free electrode against the edge of its containing chamber, and also allows room for the granules directly between the electrodes to expand when heated by the passage of current. The screw-threaded portion, *p′*, of the

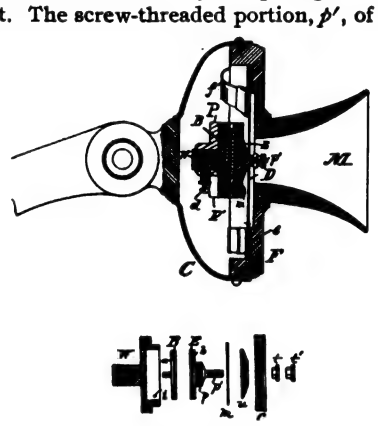


FIG. 2.—SOLID BACK TRANSMITTER.

piece, *b*, passes through a hole in the center of the diaphragm, and is clamped firmly in place by the two nuts, *t t′*. *M* is the mouth-piece of hard rubber, screw-threaded in an opening in the front block, *F*. Any vibration of the diaphragm is transmitted directly to the front electrode, *E*, which is allowed to vibrate by the elasticity of the mica washer, *m*. The back electrode is, of course, stationary, being firmly held by the bridge rod, *P*.

This transmitter is now used on all of the long-distance lines of the Bell Company, and has given excellent service on the Chicago-New York circuit, which is the longest working line in the world. It is commonly used in connection with three cells of Fuller bi-chromate battery, and stands the heavy current without being unduly heated or suffering any other ill effect.

Fig. 3, illustrates the Colvin transmitter. Although this is an efficient instrument and extremely unique in design it is very little used. The shell is formed of two pieces, *A*, provided with the usual mouth-piece, and *B*, fitting into a recess in the piece, *A*. The space *J*, in which the diaphragm fits is made large enough to hold the diaphragm very loosely so that it and the cell it carries may vibrate with great freedom under the impact of sound waves. Upon the diaphragm is supported a hollow cylindrical cell, *D*, of insulating material (shown in the small cut at the left) carrying two metallic electrodes, *E E′*, insulated from each other. To these electrodes are connected the circuit terminals, *G G*. The shell, *D*, is clamped firmly to the diaphragm, *C*, by a bolt, *F*, thus closing the chamber containing the granules. To prevent the access of moisture to the carbon granules the joint between the diaphragm and the edge of the shell is hermetically sealed. The diaphragm is of aluminum, and being loosely mounted is free to vibrate with great amplitude. One of the striking features of this instrument is that the two electrodes, *E E′*, are fixed with relation to each other, the variation in resistance being obtained by the variation in pressure between the electrodes and the carbon granules, due to the inertia of the latter, and also to the shaking up of the granules themselves, and the consequent variation of their intimacy of contact with each other.

Fig. 4 shows the Sutton transmitter now manufactured by the Phœnix Interior Telephone Company. The variable resistance parts comprise a pair of carbon buttons, *F* and *G*, each surrounded by a sleeve of cloth, *H* and *I*, the abutting edges, *h* and *i*, of which are frayed out so as to form an intimate but yielding contact. These not only serve as a damper to the vibrations of the

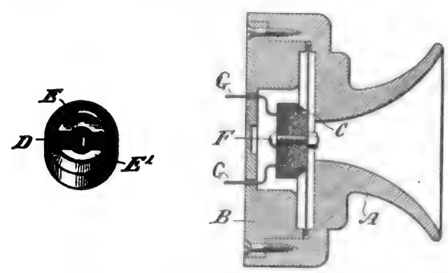


FIG. 3.—COLVIN TRANSMITTER.

diaphragm, but form with the buttons, *F* and *G*, a closed chamber in which the granular carbon is placed. The button, *F*, is secured to the diaphragm, *K*, as shown, while the button, *G*, is rigidly secured to the case of the instrument, and is insulated therefrom. The wire, *O*, leading from the bolt, *L*, which secures the button, *G*, in place, forms one terminal of the instrument, the casing itself the other.

In granular carbon transmitters much trouble has been experienced from what is commonly known as "packing." This consists in the granules settling into a compact mass by the constant agitation due to the sound waves. As a natural result the granules arrange themselves in layers according to their size, the small ones working toward the bottom. In this state the entire mass becomes very compact, thus losing the advantages of loose contact and impairing the transmitting qualities of the instrument.

Fig. 5 shows an ingenious and simple contrivance of the Western Telephone Construction Company for preventing packing. In this figure *A* represents the front of the transmitter box and *B* the brass shell containing the working parts of the transmitter. A cylindrical portion of the shell extends through the front board, *A*, and carries the mouthpiece, *M*. *C* is the hard rubber back plate of the transmitter, held in place by

two smallscrews, *a a*, fitting in the threaded ears, *b b*, of the casing, *B*. The spring, *E*, presses against the screw, *K*, projecting from the center of the back plate, *C*, and forms one terminal; the spring, *D*, having two arms, *d d*, bearing against the casing, *B*, forming the other. By manually turning the mouthpiece the entire casing of the transmitter and the parts contained therein may be rotated and the granular carbon, al-

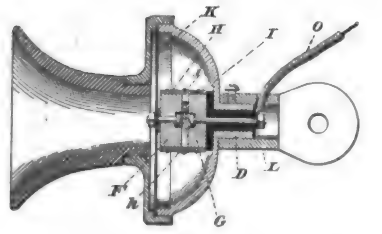


FIG. 4.—SUTTON TRANSMITTER.

ways falling to the bottom of its containing chamber is effectively stirred up. The arms, *d d*, of the spring, *D*, make a sliding contact on the casing, *B*, while the screw, *K*, turns pivotally under the spring, *E*. Circuit through the transmitter is therefore never interrupted, and it is found that an occasional turn on the mouthpiece will keep the transmitter in good order.

Fig. 6 shows one of the attempts to increase the efficiency of the microphone, but results so far obtained from this and similar

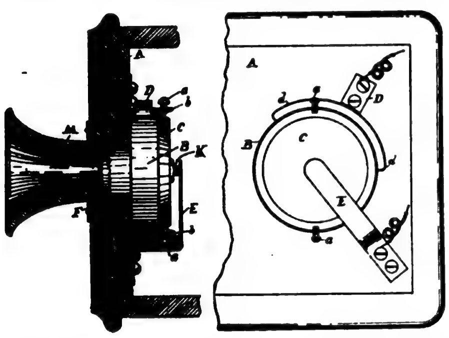


FIG. 5.—TRANSMITTER WITH MOUTHPIECE AGITATOR.

experiments have not proved of sufficient value to warrant the additional complexity of parts. This instrument consists of a double Blake transmitter, with a pair of electrodes on each side of the diaphragm. The action of the electrodes, *e* and *i*, is the same as that of the electrodes of the regular Blake instrument. The electrodes, *d* and *h*, however, being on the side of the diaphragm towards the speaker, serve also to vary the resistance of their point of contact, but an increase in resistance between *e* and *i* is accompanied by

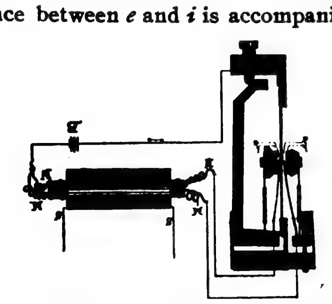


FIG. 6.—DOUBLE TRANSMITTER.

a decrease in resistance between *d* and *h*, and *vice versa*. The induction coil used with this instrument has two oppositely-wound primary coils, *M* and *N*. The coil, *M*, is in circuit with the pair of contacts, *d* and *h*, while the coil, *N*, is in circuit with the contacts, *e* and *i*. As these coils are wound in opposite directions, and as an increase of current flowing from the battery, *B*, through one of them is always accompanied by a decrease of current through the other, it follows that their inductive effects on the secondary coil, *S*, will be added.

In the development of the transmitter the tendency has been toward an increase of the number of points of variable resistance contact. The early instruments of Beliner, Blake and others were provided with a single pair of electrodes. Following these came the multiple-electrode type, originated by Hughes. To-day, the granular or comminuted-electrode type has proven its superiority over and is rapidly replacing all others.

REPAIR OF ELECTRIC RAILWAY MACHINERY.

THE PAIRING OF STREET RAILWAY MOTORS.

Almost all large companies buy their trucks and equipments separate, and are frequently assembling them, or re-assembling them as conditions of repair may dictate. It is a well known fact that two railway motors that are as near alike mechanically as human art can make them, will operate at different speeds at the same load when fed from the same sources of electric supply. If two such motors are compelled to operate at the same speed by mounting on the same truck, they will not work harmoniously, and the tendency of one machine to drive the other as a dynamo will cause the load to divide very unevenly, and the full mechanical power of the electrical energy will not be realized, while the overloaded motor will suffer from such treatment. It is obvious from these facts, therefore, that such a condition of affairs as has been just recited is to be avoided.

The reason for this peculiar action of apparently similar motors is very simple. It lies in the fact that the permeability of the steel of which the field magnets are made is very variable, and is different with different motors. Thus, one motor field case would produce a different magnetic flux than another, even though their magnetizing coils were in series and thus received the same current, and the motors were in every way exactly similar as regards construction. This most annoying property of cast steel has ruled it out of all dynamo machine construction where lightness is not a desideratum. In railway motors, however, it is necessary to use steel, and, therefore, a few remarks on the pairing of motors may be acceptable.

The best way to compare two motors in order to determine their adaptibility for mutual operation is to run them as dynamos with a known resistance in circuit, and note the resulting speed voltage and current. At the same time they can be tested for any faults they may have. In order to facilitate this testing the following appliances are necessary:

First, a source of power with a speed that can be varied at will; second, a set of resistances; third, the necessary measuring instruments, consisting of a voltmeter, an ammeter and a speed gauge.

The best source of power is another railway motor, preferably of greater capacity, the speed of which is controllable with a rheostat. If the motor is large enough to run two motors, the testing can be made much more complete.

There should be a variable resistance capable of carrying the full load current of the motors, for which water resistance will answer. The other instruments are too familiar to need description.

As has been intimated, there are two methods of testing the motors, and both of them have their advantages. The double system, which is the simplest, will be described first.

In this test, the motors are driven together by the driving motor, and as they are directly connected thereto, they operate at the same speed. They are connected together in series, with their free terminals connected to a water resistance, and the motors are thus driven and loaded as dynamos. The condition of things is shown in the diagram of Fig. 1. Thus the motors have the same speed and their armatures and fields receive the same current, so that the excitation of the magnetic circuits of both motors is ab-

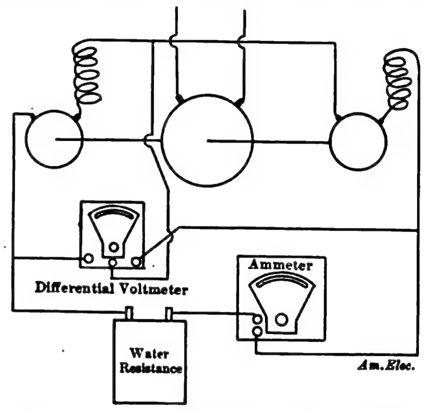


FIG. 1.—METHOD OF TESTING MOTORS.

solutely identical. If a magnetic difference exists in the motors, it will be evidenced and measured by the difference in the voltages that the motors are generating. For perfect mutual operation under given conditions of speed and current, the voltages that each generate should be absolutely the same. Practically, a few per cent. difference can be tolerated and the motors mounted on the same truck, but if the difference exceeds twenty volts, as it sometimes does, it would be well to pair each of the motors to others that would be better mates magnetically.

No better way of comparing two motors that are to operate on the same truck can be had. If a differential voltmeter be used, the inequality between the two motors will be indicated and measured directly. The test should be made with all of the practical currents and speeds, for the saturation curves of the steel of the magnets might cross and not coincide, and if that was the case, two motors that paired exactly on one speed and load would vary widely on another. The speed of the motors makes much less difference than the load, and two or three speeds will be sufficient, but at each the current demanded should be widely varied.

A very convenient modification of this

method can be applied to trucks on which the motors are already installed, in order to ascertain how well the motors pair, and this modification is an extremely practical one. A differential voltmeter is connected to the motors so that the difference of their voltages is indicated, and the car is run on the track with the controller at full series. The controller connections should be consulted in order to make sure that at full series, or any other series notches at which the car is run during the test, the fields are not shunted or otherwise connected so that the same current fails to flow in both fields and armature of each motor. This being assured, the differential voltmeter will faithfully indicate and measure at any instant just how the motors are pairing as the various parts of the trackway are reached. The mutual operation on grades, curves, descents or level tracks can thus be accurately observed.

It is important to note that a discrepancy might be due to a fault such as the short-circuiting of one or more turns on some part of one of the motors. Certainty as to the non-existence of these faults must be had before inferences may be intelligently drawn from the reading of the differential voltmeter. A discrepancy may be created by the non-equality in the diameters of the driving wheels, the motor driving the smallest wheels having the higher voltage. Similarly, allowances must be made for indications taken when the wheels are skidding, as on a curve or grade. For this reason, the indication when the brakes are applied should not be taken into consideration.

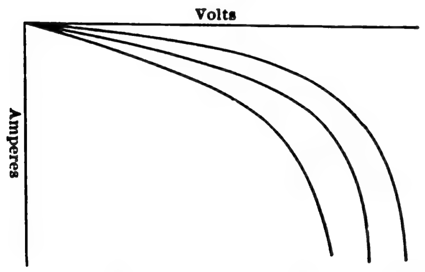


FIG. 2.—MOTOR CHARACTERISTIC CURVES.

Although this method is very accurate, it is somewhat troublesome, as frequent tests might have to be made before motors that were suited to run together could be found. This difficulty would bar out such tests on roads whose managers are not over-particular. It is also necessary, if one voltmeter is used, to be sure the current does not vary while changing the voltmeter from one motor to the other. For this reason, the differential voltmeter is far more accurate.

The second method, which tests but one motor at a time, is more practical, although it is neither as accurate nor as beautiful theoretically. The motor is driven as a dynamo at various speeds and the current that it generates is varied by a water resistance. The methods of procedure are as follows:

The motor is driven at a number of different speeds, and at each speed the current is varied from zero to full load by intervals of five or ten amperes. At each interval the voltage and current are carefully measured. These results are plotted in the form of a curve, using volts on the ordinate axis and amperes as abcissæ; there are as many curves as speeds, usually three or more. These curves are called the characteristic curves of the motors at the various speeds at which they are taken. Examples of the records are shown in Fig. 2. These curves should preferably be plotted on tracing cloth. All the other motors should have their characteristic curves taken at these same predetermined speeds and similarly recorded.

If this is done as the motors are received, or at other convenient times, it will not be long before a complete record of all the motors on the road is in hand. Of course, all of the motors are numbered or otherwise designated, and their characteristic curves correspondingly marked. When it is desired to see how two motors will operate in parallel it is simply necessary to take their curves and place them over each other on some illuminated surface, such as a window pane, and note how closely their characteristic curves coincide. The more nearly these curves agree, the better the motors will operate together, and if they are divergent at any one point, they may be expected at that speed and load to unequally divide the work between them. As the motors operate in multiple mostly at full or three-quarters load, it is obvious that it is more important that the curves coincide on their upper portions than near the origin.

The comparison of the parallel running of two machines by means of the characteristic curves, has been criticised by some authorities as a useless expedient, because it is possible to connect dynamos of different makes and capacities to the same bus bars and operate them satisfactorily. This is quite true, but those who make such statements forget to consider that dynamos when running at various load in parallel vary their fields but very little, and in this they are assisted by either automatic or hand regulation to equality. They do not operate along their natural characteristics and, of course, these curves have little or no weight on their parallel running. Series street railway motors, on the other hand, must operate in parallel under every conceivable strength of field, from a positive to a negative maximum, and they must regulate their own fields over this wide range. Of course, they do this along their characteristic curves. Therefore these curves form a highly important indication as to the parallel operation of the machines they represent.

Pole Finding Paper.

The following recipe for making pole-finding paper is given by a French authority: Dissolve from one to two parts (15 to 30 grains) of phenol phthalein in 10 parts of alcohol, and pour the solution into 110 parts of distilled water. In another vessel dissolve 20 parts of sulphate of soda in 100 parts of distilled water. The parts are all by weight. The first solution is then poured into a porcelain tray, and several sheets of slightly porous paper are dipped into it one after another. These sheets, after being allowed to drain, are immersed, while still damp, in the soda solution. The paper after being dried is extremely sensitive to the action of the electric current.

INTERIOR WIRING.

BY GEORGE T. HANCHETT.

ALTERNATING-CURRENT WIRING.

Alternating-current wiring differs from direct-current wiring in some important details which should be known to the wireman. The reason for this difference is found in the fact that, owing to a peculiar property of alternating currents, the loss of volts in the line is usually somewhat greater. This extra loss in volts arises from a very different cause from that of the ohmic resistance of the line. The line always has the same resistance whether the current be direct or alternating. This additional cause of loss of voltage is called the *reactance* and only asserts itself when alternating or rapidly-varying currents are used. The combined retarding effect of the reactance and resistance is called the *impedance* of the line.

Reactance consists of two factors, one of which is known as the inductance and the other as the capacitance of the circuit. The inductance tends to retard and the capacitance to assist the flow of the current. It sometimes happens that this new factor appearing in alternating current lines has a negative value and actually assists the flow of current through the wire, sometimes making the voltage available at the end of the line greater than that impressed at the receiving end. When this factor has such a value that tends to counteract or eliminate the effect of the resistance, capacitance is said to prevail. This curious effect of an increased terminal voltage with lines of large capacitance puzzled experts a long while, and while this state of uncertainty existed it was named the Ferranti effect, because it was first noted in a marked degree on the Ferranti mains at Deptford, England.

It is evident that any circuit which possesses a marked reactance cannot be calculated by the ordinary direct-current methods. Something more is necessary and that it is the aim of this article to provide. Before submitting the formulae and curves, a brief discussion of these two new factors in wiring will be interesting and opportune.

The student of electrical matters has early learned that a wire carrying a current is surrounded by a field of magnetic force, the lines being at right angles to the wire at every point and therefore forming a circle about the wire in a plane at right angles therewith. Another elementary principle is that a wire cut by, or cutting, lines of force has generated in it electromotive forces due to such cutting. It is only necessary to apply these principles to a wire carrying an alternate current to get a sufficiently clear idea of inductance for the purposes of interior wiring.

It is evident that if the current is a constant direct current, the magnetic field it generates will be both steady and constant, but if the current be alternating and continually fluctuating between a positive and negative maximum value, the field that it creates will be fluctuating also, and lines of force will be continually sent out and called in, in order to keep their number exactly proportional to the current the wire is carry-

ing. Any conductor placed in this moving field of force will be cut by these lines, and electromotive forces will be generated therein. The conductor to which the lines of force owe their existence is no exception to this law. Therefore, as the pulses of current oscillate back and forth in the wire, little pulses of electromotive force are generated in it, due to the field outside, and these pulses are so timed that they interfere with the impressed electromotive force and reduce its effective value. It is easy to see that this is a property essentially belonging to alternating or fluctuating currents. The pulse of induced electromotive force collides, as it were, with the impressed electromotive force, rendering their difference only effective.

Capacitance is also due to electromotive forces other than the impressed electromotive force existing in the wire, but these electromotive forces are due to an entirely different cause. To understand this a comprehension of electrostatic capacity is necessary. If two plates are charged from a source of electricity and these plates are carefully insulated from each other, they will retain their charge after the wires are removed, and if they are connected together a pulse of current will flow till equilibrium is restored. These plates may be of any shape and size and may be any distance apart; the insulator may also be of any kind, and on these magnitudes just enumerated the capacity effect depends. It has been common to describe a condenser as two conductors separated by an insulator. Every electric circuit contains this and therefore every electric circuit has capacity.

Now, if the impressed electromotive force on a condenser is steady, the condenser will simply be filled with electricity at that pressure, and no other effect will be apparent. If, on the other hand, the current is alternating, the condenser will have a chance to discharge into the line at the instant when the electromotive force impressed upon it becomes zero or nearly so, and these pulses of electromotive force are so timed that they *assist* the flow of current in the wire. This phenomenon is called capacitance and, like inductance, only asserts itself when the current is pulsating or alternating. Below are enumerated the factors affecting reactance.

Great capacitance results from the following conditions:

Conductors of large superficial area, such as ribbons or concentric tubes; minimum linear distance between conductors; high specific inductive capacity of the separating insulator, a peculiar and special property.

High inductance is caused by high frequency of pulsation of the alternate current; strong magnetic field generated thereby, which in turn, depends on the area of the circuit, and the presence of magnetic material, such as iron, within it.

In interior wiring the phenomenon of capacitance is seldom noticed because it is entirely overshadowed by the more prominent inductance effect. In fact, capacitance is seldom, if ever, noted except when the wiring is on the concentric system in which one of the conductors is a tube and contains the other.

The aim, therefore, should be in alternating-current wiring to arrange the circuits so as to have as little inductance and as great a capacitance as possible, and then to calculate the wire by a formula that takes these factors into account and gives the wire sufficient extra conducting power, in order that the ohmic drop will be reduced so as to make up for the inductive drop that is unavoidable.

To do this the following conditions should be observed: The lead and return wires should be as near together as possible; this both reduces the reactance and increases the permittance. The circuit should avoid the form of a coil and should contain no iron. The wires should be as small as possible. A number of specific cautions will be mentioned, for although they are suggested by the general cautions already given, they are examples of application and cover some very common cases.

When iron-armored conduit is used, the two wires of a circuit should be run in one tube, for otherwise the circuit will contain iron to such a degree that the use of an enormous cable which would practically eliminate the ohmic drop would still insufficiently reduce the impedance of the circuit.

It must be distinctly remembered that increasing the size of the wire does not appreciably diminish the inductive drop. It diminishes the resistance, and by thus reducing the ohmic drop renders the inductive drop more endurable. Loop circuits, which are so useful in direct-current wiring, are too inductive to be used in alternating-current wiring except in cases of a small system.

In running out a large number of leads from a cabinet, the common practice of bunching the wires of like polarity, will result in an increased reactance of that part of the circuit, while the bunching of unlike wires will practically eliminate it. The re-

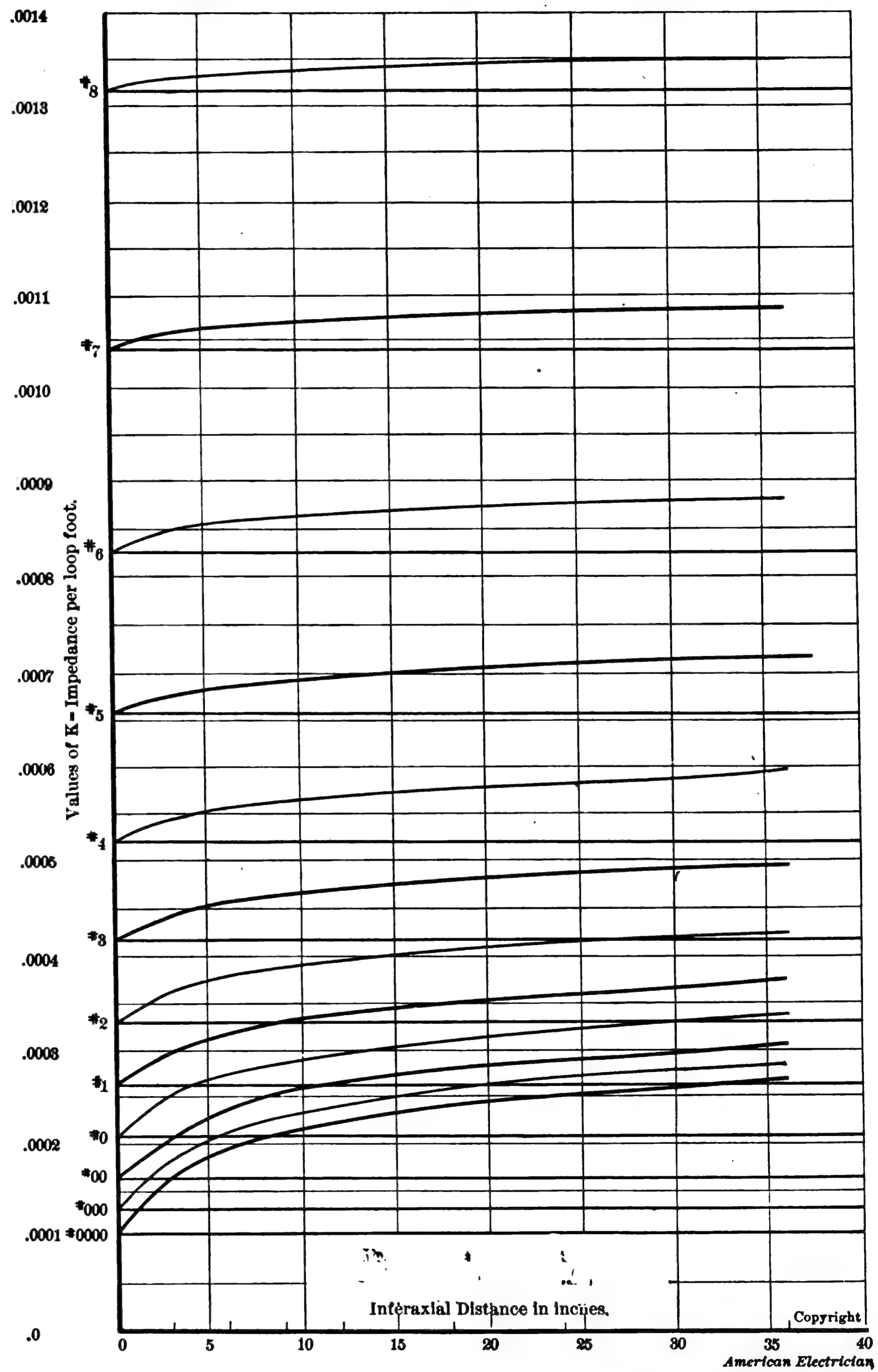


FIG. I.—ALTERNATING-CURRENT WIRING CURVES FOR 7200 ALTERNATIONS PER MINUTE.

actance effect may be so great that it will pay to adopt the latter expedient and increase the insulation of the wiring.

If a closed loop be placed so as to coincide with a loop of wire carrying alternating currents, currents will be generated therein and will neutralize the effect of inductance to a considerable extent. Therefore, when running alternating-current wiring in separate metal-armored tubes, it will be well to connect the outer armor of the two tubes at intervals and thus reduce the inductive drop.

Turning now to the calculation of a circuit, the student is referred to the accompanying curves. It would be tedious and incomprehensible to many to follow the theory by which they were deduced, but any one can practically apply them. There are two sets of curves, one for the frequency of 15,000 alternations per minute and the other for 7200 alternations per minute. Both of these are frequencies that the interior wireman is likely to encounter.

The line loss is assumed as in direct current wiring, and the length of the circuit (single distance) is also known. The current to be carried is determined by calculation from the number of lamps in circuit. The rule is as follows:

Divide the line loss by the amperes to be carried and by the distance in feet. This gives a numerical quantity called K. Search out the value of K and of the interaxial distance of the wires on the axes of the curves given. Follow the ordinate and abcissa thus indicated to the point where they intersect, and choose the wire corresponding to the nearest curve. The nearest straight line corresponds to the wire that should be used if the system be one of direct currents, and it will be seen that a notable difference exists. It will be noted that the straight lines are the same for all interaxial distances and frequencies, which, of course, is to be expected. With these two charts almost any interior circuit can be calculated.

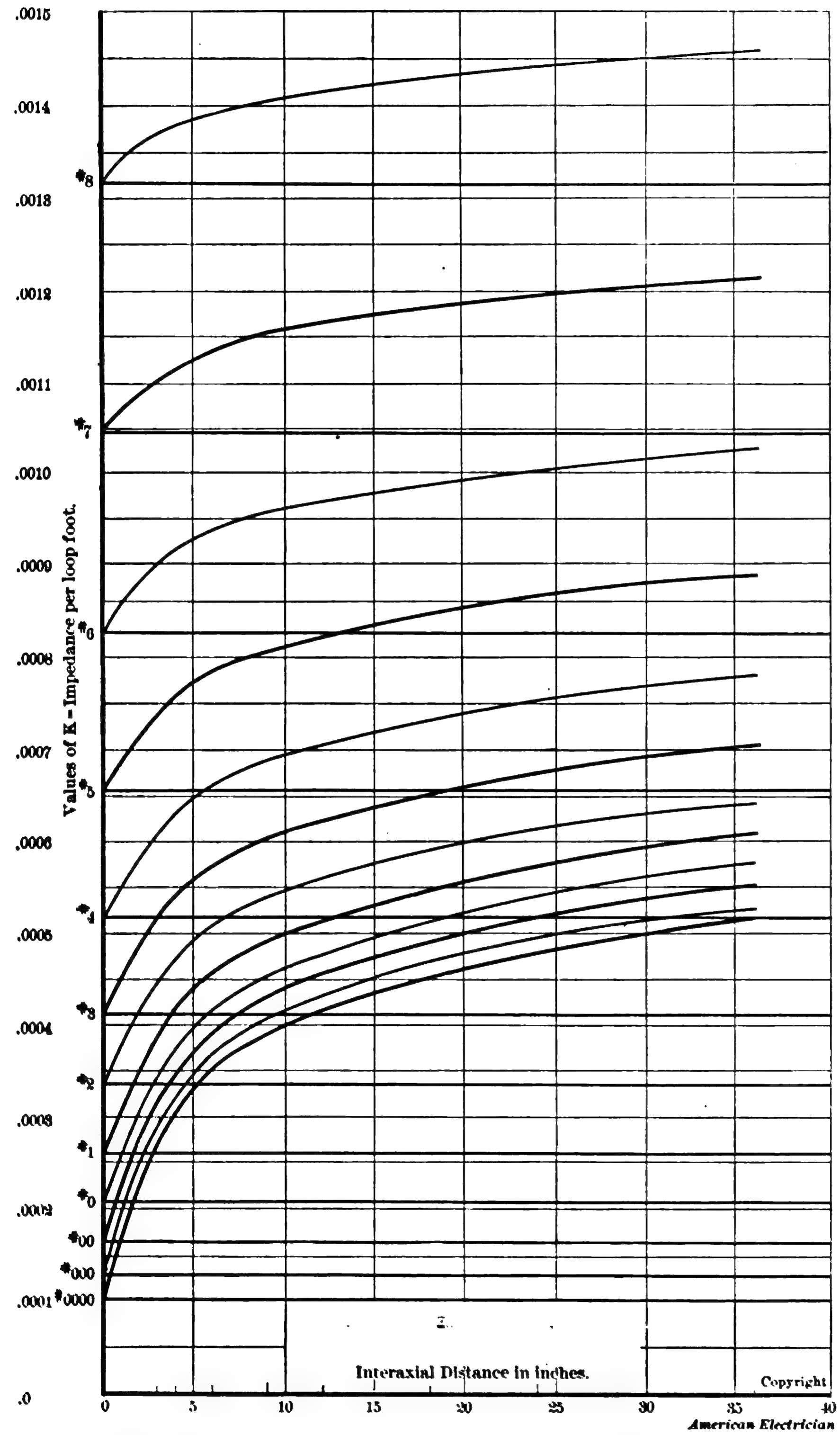


FIG. 2.—ALTERNATING-CURRENT WIRING CURVES FOR 15000 ALTERNATIONS PER MINUTE.

FAULTS AND HOW TO FIND THEM.

FAULTS IN ARC LAMPS.

Arc lamps are built so differently that a review of the possible faults of every type would constitute a book in itself, and consequently attention in this article will be confined to the faults that are common to the various classes. Special mechanical troubles must in a great measure be excluded, and the available space be devoted to the electrical ones.

There are three commercial circuits on which arc lamps are burned, namely, the constant current where the lamps burn in series, and the constant potential, both alternating and direct, in which the lamps burn in multiple or multiple series. There is further the 500-volt railway current in which the multiple-series system is used.

The series arc lamp system, which was the earliest in use, employs lamps which may be divided into classes according to their mechanism and the way in which it operates. There are two great classes, the open and the closed-circuit lamps. The distinguishing feature in these is, that in the open-circuit lamp the carbons are apart on starting, and fall together and then separate upon drawing the arc. With the closed-circuit lamps the carbons are together on starting, and when the current flows the carbons simply separate and the arc follows. The electrical mechanisms are of two kinds: First, the differential mechanism, and second, the shunt mechanism, which latter has only lately appeared on the market. Both of these mechanisms employ a coil of coarse wire and another of fine wire. The coarse wire coil is in series with the main circuit, and is known as the series coil, while the finer coil has its terminals connected to the terminals of the lamp, and is therefore in multiple with it.

It is easy to see that the series coil will only operate its mechanism when the current varies in strength, while the shunt coil will move its mechanism when the arc becomes too long or too short, or when the potential at the terminals of the lamp varies. Therefore, in any series arc lamp the shunt coil is the one that does the regulating and feeding because the current is automatically kept constant by the dynamo that feeds the system, and therefore when the current is once on, the strength of the series coil does not vary.

The series coil is used to start the lamp, and its action is as follows: The current being turned into the lamp the series coil is energized, and moves the carbons apart if the lamp is a closed-circuit one, and its influence on the mechanism of the lamp remains the same as long as the lamp is burning. As soon as the carbons are burned

apart to any considerable extent, the shunt coil becomes so powerful as to overcome the influence of the series coil and moves the carbons nearer together. Presently the carbons are still more consumed and the shunt armature is attracted so powerfully that the mechanism is released and the lamp feeds.

With the open-circuit lamp, on the other hand, the series coil is not in circuit until after the lamp is started. The shunt coil

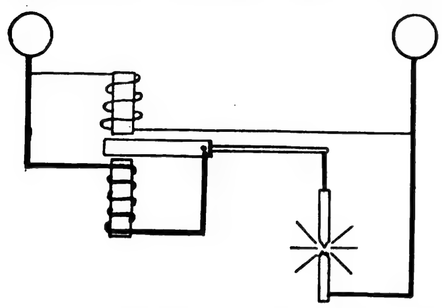


FIG. 1.—DIAGRAM OF DIFFERENTIAL ARC LAMP.

drops the carbons together, a strong current flows, and the series coil pulls them apart again, thus drawing the arc, after which feeding and regulation is accomplished in precisely the same way as in the closed-circuit lamp.

The diagram of Fig. 1 shows the principle of the differential series arc lamp, and by consulting it the foregoing may be more easily understood.

The shunt lamp for series system has a series coil, it is true, but this coil is cut out after the lamp has been started, the separation of the carbons being accomplished by weights or springs. This lamp has the advantageous feature that variation of the strength of current does not materially affect it. Fig. 2 is a diagrammatic representation of this system. All of these lamps are provided with a cut-out which short-circuits the lamp in case an accident occurs to the mechanism.

Arc lamps may be further divided into clutch and rack-feed lamps. The former employ a friction clutch which acts on the feeding mechanism, and the latter use a rack and pinion to work the carbons and control the spindle on which the pinion is mounted. Clutch lamps will be considered first.

These facts being understood, some of the faults that are likely to occur may be discussed. Like the faults in any electrical device, they are due to short circuits, open circuits or grounds in some part of the electrical system. If one of the electrical circuits rings on to the frame of the lamp when tested with a magneto, that does not necessarily indicate a fault, for some lamp frames are intentionally grounded. Supposing the inoperative lamp to be one of the closed-circuit type, shut off the current and see if the ends of the carbon are together and will lift apart freely. It sometimes happens that the ends of the carbons do not nose properly and fall past each other, wedging the mechanism so that it becomes inoperative.

If a lamp appears externally all right, it may start with a shake or a jar, and although this may answer for a time, the lamp should be immediately noted as one that needs repair. If this examination is made in the repair shop, of course the case should be opened and examined. Look first to the automatic cut-out and see if that is open. If such is the case, the series coil, the shunt coil, or the lamp itself may be short-circuited. If the shunt coil or the lamp is short-circuited, the latter will not operate till the short circuit is removed, for such a fault has precisely the same effect as throwing the cut-out switch. If the carbons are lifted apart, no arc will follow and as soon as they are released they will fall together again.

In some few lamps, the shunt coils are connected across the carbons. In such a case the series coil would hold the carbons wide open, and would open them if they were forced together, but there would be no arc because the gap between the carbons is short-circuited. If the short circuit between the shunt coils were only partial, and a few amperes only were diverted from the arc, the latter might operate, but the shunt bobbin would get very hot and would ultimately burn out.

If it be the series coil that is short-circuited, the lamp will not start, but if the carbons are separated by hand an arc will follow. What happens next depends upon the form of the mechanism. If the lamp is electrically a differential one, that is, the shunt and series bobbin act on the same core and neutralize each other's effect, the shunt bobbin will attract the armature in just the

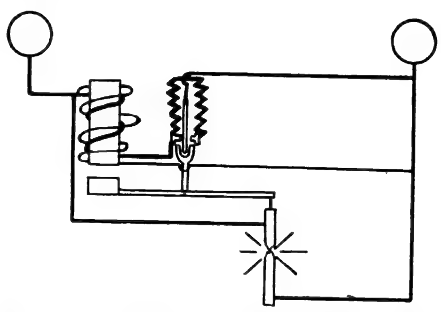


FIG. 2.—DIAGRAM OF SHUNT ARC LAMP FOR SERIES CIRCUIT.

same way that the series bobbin would, and will hold the carbons open the more firmly as the arc burns longer and longer, unless the cut-out is arranged to operate and prevent this. If, on the other hand, the lamp is mechanically differential—that is, both bobbins pull in opposite directions on the same armature—the increasing strength of the shunt bobbin will suddenly cause the carbons to run together, and the arc will cease, for there is no operative series coil to re-establish it.

If the lamp be of the open-circuit type, the symptoms of short-circuited shunt and series bobbins are different. If the shunt bobbin is short-circuited, the carbon will remain apart, no matter how the series coil is connected, but if it be connected across the carbons simply, it will be notably harder to press the latter together, for the series coils assist the weights or springs. If the series coil is short-circuited, the lamp will chatter and flash. The shunt coil will permit the carbons to run together, and as soon as they touch, the shunt coil loses its energy and the weights or springs will separate the carbons. The shunt coil will act again and the carbons will be brought together, and so the chattering will proceed in much the same way as does the vibrator on an electric bell. If the weights or springs be made strong enough, the lamp may operate, but if the shunt bobbin has been constructed to operate against the combined influence of the weights or springs and the series coil, the loss of the force of the latter by short-circuiting will allow the shunt coil to have everything its own way.

Turning to open circuits as a source of trouble, it may be said of all series arc lamps that to open circuit in the main circuit, which includes the series coil, is impossible. If the circuit of a large modern arc machine were opened by special means, an arc from two to five feet long would follow, and it is obvious that if a break should occur within the limited confines of the box containing the lamp mechanism, an arc would be formed of sufficient stability to allow the current to flow and the lamp mechanism would suffer. This would not occur, however, for all modern arc lamps have a cut-out device which prevents such accidents.

Open circuits in the shunt coil, however, disable it and the carbons will burn apart till the cut-out acts. If the lamp is of the open-circuit type, it will not start unless some outside influence is brought to bear, and once started it will behave precisely as the closed-circuit lamp.

The shunt arc lamp for series circuit is a special production of the Adams-Bagnall Company, of Cleveland, O., and its radical difference from other mechanisms in electrical details makes it worthy of mention. When this lamp is quiescent and no current flows, the series coil is cut across the terminals. The flow of current actuates this coil and it pulls its armature, the motion of which brings the carbons together and cuts out the series coil, which instantly drops its armature. The carbons come apart, drawing an arc after them, and the shunt coil thus brought in play catches the armature as it falls, and regulates and feeds the carbons. Its action is balanced by an ingenious system of weights. If the series coil of such a lamp were short-circuited, it would refuse to operate, but if started by artificial means, it would continue to run, for in its running position the series coil is cut-out and a fault in its winding does not affect the lamps. The short-circuiting of the shunt coil would in this lamp be equivalent to

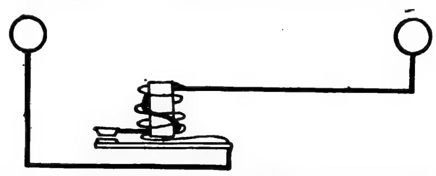


FIG. 3.—DIAGRAM OF AUTOMATIC CUT-OUT.

short-circuiting the lamp itself and it would refuse to operate.

Automatic cut-outs are now in general use on series arc lamps, and a little description of their principles and action is essential to the investigation of faults. The office of such cut-outs is to short-circuit the lamp when the circuit within the lamp is broken either by the falling out of a carbon, the failure of a wire or other cause. When such an open circuit occurs, the potential at the lamp terminals raises enormously.

Therefore, as would naturally be supposed, the cut-out, if it be electro-magnetic, is actuated by a coil, either in series with the shunt bobbin or itself shunted across the lamp terminals.

Since when the lamp is thus short-circuited, the potential difference at the lamp terminals is practically zero, the shunt cut-out bobbin would fail in its function, as in cutting out the lamp it also cuts out itself. This is provided for by the introduction of a series coil at the instant that the shunt coil is cut out. The arrangement is diagrammatically shown in Fig. 3. If the series coil becomes disabled on such a device by short-circuiting, the cut-out will flutter open and start pulling an intermittent arc at its contacts. If the shunt coil is disabled and inoperative, the cut-out will not act and serious results may result if its action should be called for.

Some lamps use a mechanical cut-out to short-circuit the lamp after the carbons have been burned out. This is usually accomplished by allowing some projection on the feed-rod to descend upon and operate a mechanism.

The rack-feed lamp differs from the clutch lamp only in mechanical detail. Its electrical contact is substantially the same. The pinion which engages in the rack drives a train of wheels terminating in an escapement, precisely the same as in an ordinary clock. Instead of being controlled by a pendulum, the escapement is controlled by an electro-magnetic mechanism. As a usual thing, a rack feed is preferable to a clutch where both are in order, but the complication of the power renders them unsuitable for operation in exposed places.

The subject of faults in constant potential lamps will be taken up in another article.

THE SLIDE VALVE DIAGRAM.

While a knowledge of the slide valve diagram is by no means indispensable to the steam engineer, yet he cannot be said to intelligently understand the action of his engine or to be thoroughly equipped for the interpretation of indicator cards, until he does possess this knowledge. There are also cases when the principles of the valve diagram are of direct practical application, as in adjusting, cut-off, compression and lead, and accounting for abnormalities in the shape of an indicator card.

In what follows the geometry of the valve diagram will be neglected and merely its practical construction treated. This will simplify the subject to such an extent as to require little or no trouble in its understanding by the practical engineer.

To lay down a valve diagram, there are usually required to be known, the travel of the valve, the full opening of the steam port, the exhaust lap and the angle at which the eccentric is set ahead of the crank pin. These data may be obtained as follows:

Wire to the valve rod a sharp point, jack the engine several turns and let the point trace a line on a board having a surface, say, of lamp black or tallow. The length of this line will, of course, be the travel of the valve, and is preferably to be taken off with dividers, for it is always practicable to lay down a valve diagram to at least full size. Next, jack the engine until the tracing point shows the valve to be at the inboard end of its throw; then, the valve sheet cover being off, measure the full opening of the steam port, or, preferably, take off the width of the opening with a pair of dividers.

To lay down the exhaust lap, it will be necessary to know the full width of the steam port, and the distance on the valve face between the steam and exhaust edges of the valve. How the exhaust lap is obtained from these data will be shown later.

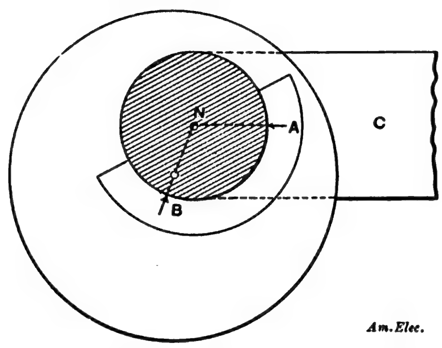


FIG. 1.—METHOD OF OBTAINING ANGLE BETWEEN CRANK AND ECCENTRIC.

Finally, the angle between the crank and eccentric is to be determined, which may be done as follows: On the engine shaft at the eccentric, make a punch or other mark, A (Fig. 1), in line with the crank; similarly make a mark, B, in line with the highest point of the eccentric. On the edge of a piece of paper cut to an arc of the diameter of the shaft, lay off these two points; then, by drawing a circle of the same diameter as the shaft and marking these points on its circumference the desired angle may be found, as shown in Fig. 1.

We are now ready to lay down the valve diagram. Referring to Fig. 2, first draw a horizontal line, $A\ B$, and then lay down the angle just determined, which will give the line, $L\ D$. From where $L\ D$ cuts $A\ B$, or from O, lay off the distances, $O\ L$ and $O\ D$, each equal to half the travel of the valve, and draw on these lines the two circles, marked steam and exhaust. Next, measure off the distance, $C\ E$, equal to the full steam port opening, and with O as a center, draw through E the arc, $U\ E\ V$, of a circle, as shown. This latter is called the lap circle, and the distance, $O\ E$, is the steam lap of the valve.

To find the exhaust lap, from the distance on the valve face between the steam and exhaust edges of one side of the valve, subtract the sum of the port width and of the steam lap; with a radius, $O\ F$, draw the exhaust valve circle, $W\ F$, which completes the construction.

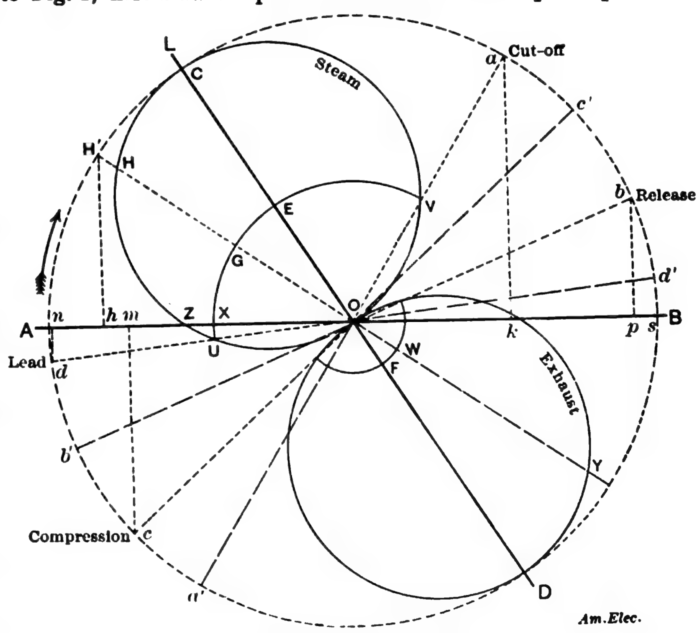


FIG. 2.—VALVE DIAGRAM.

In the valve diagram of Fig. 2, as laid down before reduction, the angle between the crank and eccentric was 33 degs., the valve travel was 3 ins., and the full port opening 13/16 in., which gives a steam lap of 11/16 in. The width of the valve face is 1¾ ins., from which we find the exhaust lap to be ¼ in. The diagram of Fig. 2 is laid down full size; in practice, with the above dimensions the scale would be two or three times actual, in order to get a more accurate construction.

Now, as to what the valve diagram shows. If we draw any radial line, as $O\ H$, then the distance, $G\ H$, intercepted by the steam and lap circles will give the steam opening of the valve when the engine crank has advanced through the angle, $A\ O\ H$ (neglecting angularity of connecting rod), or a distance $n\ h$, of the full stroke, of the engine or $n\ s$; similarly, $W\ Y$, gives the opening of the exhaust port at the same instant. As the diagram is laid down to scale, the length of these intercepts measured in inches give the actual values of the port openings.

The motion of the crank is from the dead center, A, in the direction of the arrow, instead of from B against the arrow, as would seem should be the case on account of $B\ O\ L$ being the real angle between the crank and eccentric. The anomaly is due to the geometry of the construction, and can be dismissed with a warning not to be confused by it.

Since the intercept measures the port opening, it is evident that the steam is about to be admitted at U, and that when the crank is on its center, the valve is open by an amount, $Z\ X$, called the lead. The valve is full open at C, and steam is cut off at a. Both steam and exhaust exits are closed from a to b, during which time, while the piston is going from k to p, the steam expands. At b the exhaust port opens and, as will be seen, has a large opening or lead, when the crank is on its center; the exhaust port closes at C, and as the steam port does not open until d, there is compression while the piston is going from m to n. The continuation of the lines $a\ O$, $b\ O$, or $O\ a'$, $O\ b'$, refer to the return stroke, though the intercepts, $O\ V$ and C, are the same for both strokes. Were it not for the angularity of

the eccentric rod, it would not be necessary to continue the lines, *a O* and *C* beyond *O*, as the events of each stroke would occur at the same corresponding points of both strokes.

In practice, however, it is necessary to take into consideration the angularity of the connecting rod, and this is done in the following manner: With a radius (Fig. 3) indicated by *M R* and *N R*, whose length is as many times greater than *A B* as the length of the connecting rod is greater than the engine stroke, draw the arcs *M M* and *N N*. In Fig. 3, the ratio of the connecting rod to the stroke has been made 1½ in order to exaggerate the effects.

It is evident that when the crank proceeds from *A*, around to, say, the point of cut-off,

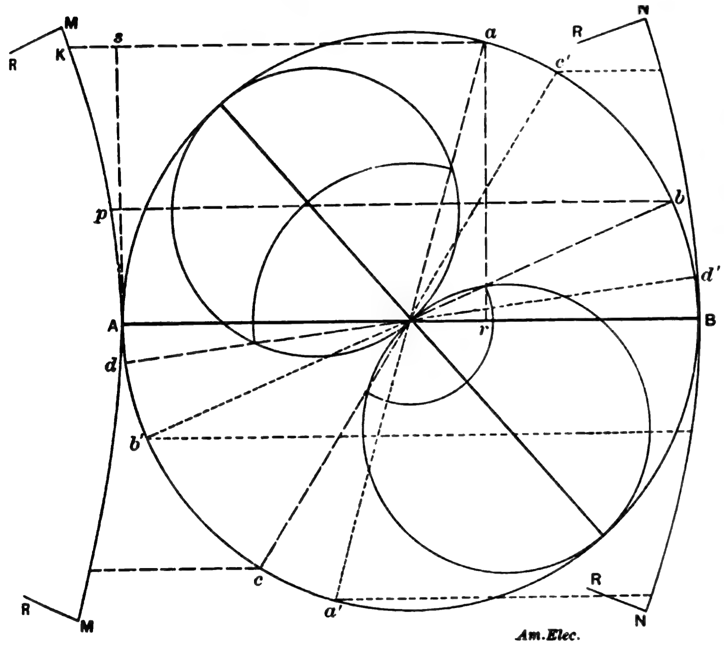


FIG. 3.—VALVE DIAGRAM.

a, the piston will have followed from *A* to *r*, if the angularity of the eccentric did not intervene, or, which is the same thing, from *s* to *a*. With, however, a connecting rod of the length assumed and with the diagrammatic construction given, when the crank pin is at *a*, the piston has advanced a distance, *k a*, instead of *s a*, or an additional distance equal to *k s*. For the other side of the piston, on the contrary, it will be seen that the corrected distance will be less, instead of greater, owing to the curvature of the connecting rod arc being toward instead of away from the circle.

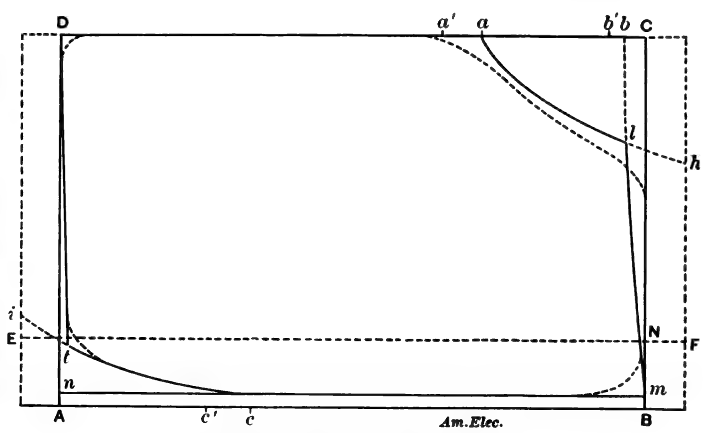


FIG. 4.—IDEAL INDICATOR CARD.

In Fig. 4 an ideal indicator card is laid down to correspond to the indications of the valve diagram of Fig. 3. The length of *A B* is equal to the diameter of the large circle in Fig. 3, and is a line of no pressure, being 14.7 lbs. by scale, below the atmospheric line, *E F*, while *C N* is the gauge admission pressure. The clearance area is laid off on each side of the card in order that the form of the hyperbolic expansion and compression curves may be obtained.

The ideal card for full stroke would be a rectangle, *D C m m*, as shown. From the diagram of Fig. 3, the various events of the stroke are transferred to the card, the distance, *K a*, for example, being *D a*, the distance *p b*, being *D b* and *C*. From *a* the hyperbolic curve, *a h*, is drawn; from the points of release *l*, a line is drawn to meet the back-pressure line at end of stroke; from the point of compression, *C*, another hyperbolic curve, *c i*, is drawn, and finally, the line of lead.

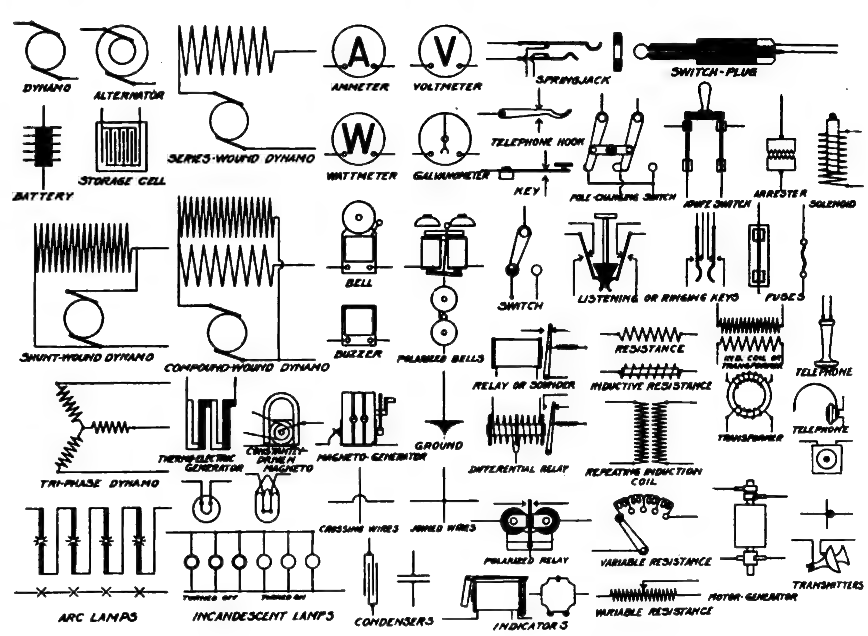
The ideal card, therefore, corresponding to Fig. 3 is the area *D a l m t D*; or if we smooth off the corners and allow for some wire-drawing, as shown by the dotted lines, we get a card similar to what may be given by the engine itself under the conditions assumed in the diagram.

The card shown is for the left side of the piston. For the right side it will be seen that the cut-off will be earlier, or at *a'*, on account of measuring from the right hand or concave curve. Similarly, release will be at *b'*, compression at *c'*, and admission slightly earlier. In drawing an ideal card from a valve diagram, it is advisable to construct the fundamental rectangle on semi-transparent paper, and then obtain the position of the various events by superposing the paper on the drawing of the diagram and marking the corresponding points.

In a following article, the effect will be illustrated, by means of the valve diagram, of altering the angle of the eccentric and the travel of the valve, which is the method employed for governing automatic cut-off engines, the angle and throw being simultaneously altered. In this article it has been assumed, for the sake of simplicity, that when the valve is at either end of its travel, the edge of the steam side of the valve is in line with the edge of the port. In the next article the effect on the diagram of an over-travel will be shown.

CONVENTIONAL DIAGRAMS OF ELECTRICAL APPARATUS.

In a paper read by Mr. D. W. C. Tanner, before the Chicago Electrical Association,



CONVENTIONAL DIAGRAMS.

the desirability of a conventional diagrammatic notation for electrical apparatus was dwelt upon, and a system suggested, which is illustrated in the accompanying engraving.

The symbols shown were selected as being those which, on careful comparison with others, seemed to Mr. Tanner to be the best adapted for the purpose. Where more than one symbol is given for the same device, the simpler form is intended to be used where it is desired to show a number of the devices, and that which bears a somewhat closer resemblance to the original will be best adapted where only one or two are required. The intention is not to show the circuits and mode of operation of complex systems or mechanisms, but only to indicate symbols for the elemental or unit pieces or apparatus, which may be combined at pleasure.

Relation of Speed and Eddy Currents of Dynamos.

Mr. Arnold Hansard, in an article in the London *Electrician* finds, by an analytical examination that the highest dynamo efficiency is obtained when the eddy current losses are equal to the armature copper losses. This conclusion is based on the assumptions of the output of a dynamo varying as the speed, the armature copper loss at full load being the same as for all speeds, and with hysteresis and frictional losses proportional to the speed and eddy current losses proportional to the square of the speed.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

The name of Becquerel is one inseparably linked with the development of modern electrical science. Three generations in direct descent of savants of that name—Becquerel ainé, Becquerel fils and Becquerel jeune—have made this branch of science their own, and from 1815 to the present day one or the other has taken part in almost every one of the great developments it has received during that period. Very recently new lustre has been added to the name from the discovery by the youngest representative, of a new form of radiation similar to Röntgen rays, known as Becquerel rays. The recognition accorded in this nomenclature compensates, to some extent, for the injustice done the progenitor of the family through the use of the name Daniell to designate the voltaic cell of Becquerel's discovery, which cell was the first of the constant-current type.

Antoine César Becquerel (1788-1878) was educated at the Ecole Polytechnique, and upon graduation entered the corps of army engineers. Being immediately ordered to the front, he took part in the entire campaign in Spain and manifested such marked ability that four years later he returned to Paris to receive the rank of captain and be presented with the cross of the Legion of Honor from Napoleon's own hands. Owing to ill health, in 1815 he resigned from the army, and thenceforth devoted himself exclusively to the pursuit of science.

It was in electro-chemistry, of which science he divides honors with Davy as the founder, that the elder Becquerel did most of his notable work, but almost every branch of electricity benefited from his ceaseless activity. He was the first to put the measurement of electrical resistance on a practicable basis. At the time when he took up this work (1825), constant currents could not be obtained and he invented the differential galvanometer in order to secure accurate results with the polarizable types of batteries then known, which were little more than modifications of Volta's original single-liquid "crown of cups." He also made many researches in thermo-electricity and formulated the well known electro-thermic series having bismuth at one end and antimony at the other. Atmospheric electricity also received much attention from him, and his latest work was in the development of electro-capillarity.

Becquerel ainé was the leading antagonist of the Volta contact theory, and greatly extended the ideas of Fabroni concerning the chemical generation of electricity. The theory which he maintained was that the electric current is due entirely to chemical action; that contact plays no part, the appearance of its doing so arising from the fact that in all chemical combinations, either positive electricity or negative electricity is produced, depending upon whether the chemical process is comparable to an acid or to an alkali reaction.

The two greatest discoveries of the elder Becquerel were the principles of voltaic polarization and the constant-current voltaic cell. In 1829 he explained that polarization is due to the presence of elements deposited from the electrolyte, whose effect is to set up an opposing E. M. F. He pointed out how it might be avoided, describing a cell in which a parchment diaphragm separated a polarizing fluid (nitrate of copper) from an exciting fluid (nitrate of zinc). In 1835 he constructed a similar cell, in which the depolarizing fluid was nitric acid. A year later Daniell brought out the cell which bears his name and which is identical in principle with the earlier one of Becquerel, but having a more practical form. In 1839 the Becquerel principle was also applied by Grove (whose death occurred but a few months ago), who credited the French savant with priority over Daniell; and Bunsen, in 1843, gave it still another application in the cell which bears his name.

ANTOINE CÉSAR BECQUEREL.

In the celebrated controversy between Volta and Galvani, the latter made a telling point by showing that two metals are not necessary to produce a manifestation of electricity, thereby apparently refuting the contact theory. Volta, however, in turn established the fact that contact by one metal with two different electrolytes is equivalent to the contact of two different metals. Becquerel made a thorough study of this phenomenon and finally devised a practical two-liquid, one-metal cell. This consisted of a glass jar containing nitric acid in which was placed a porous pot filled with a solution of soda. A platinum electrode was plunged in each liquid, and, when the exterior circuit was closed, a sensibly constant current flowed.

In 1834 the elder Becquerel observed the deposition of metal on one of two electrodes introduced into solutions of the salts of the various metals, and shortly after discovered that metals could be evenly deposited out of a solution upon an electrode by means of the electric current. On these facts De la Rive and others immediately founded practical processes for electroplating, which Becquerel rapidly improved by the addition of new facts.

The first systematic treatise on electricity and magnetism was written by Becquerel ainé, having been published in seven volumes, 1834-40, and long remained the standard authority. He was the author of a number of other books on electrical subjects, including a history of electricity, in which his son Edmond collaborated. In all, his writings comprise 529 books and memoires. A type of the true savant, Becquerel, like Faraday, confined himself to scientific research and investigation, leaving to others the practical application of the facts discovered and the pecuniary benefit to be derived from their commercial exploitation.

Of the two sons of the elder Becquerel, one, Louis Alfred, became a celebrated professor of medicine, and the other, Edmond (born 1820), followed in his father's footsteps, devoting himself to physics and chemistry, and occupying chairs in several different Parisian institutions of higher learning. One of his earlier discoveries was that oxygen is a magnetic body, and he has done much work in diamagnetism. He has paid great attention to spectrum analysis, particularly with respect to the ultra-violet portion, and was the first to photograph the spectrum far beyond its visible portion. His most notable work, however, has been in color photography, all of the fundamental principles of which he founded.

Henri Becquerel (born 1852), known until the death of his grandfather as Becquerel jeune, is at present a professor at the Conservatoire des Arts et Métiers, Paris. He has written a number of memoires on electrical subjects, and particularly with reference to the electro-magnetic polarization of light, the influence of terrestrial magnetism on the atmosphere, and the infra-red spectrum. His most recent discovery is that certain bodies after being exposed to the influence of light, will give off rays having the extraordinary property possessed by Röntgen rays, of penetrating densely opaque substances.

The very extended work of the elder Becquerel in two-liquid, one-metal voltaic cells, recalls the fact that in 1843, Prince Louis Napoleon, afterwards Emperor, but at the period named in very straitened circumstances when not a political prisoner, announced to the French Academy of Science that he had constructed a cell on that principle. The cell was formed of two copper electrodes, one plunged in a dilute solution of sulphuric acid and the other in a dilute solution of nitric acid, the two solutions being separated by a porous diaphragm. Later, when Emperor, Louis Napoleon offered a prize of 50,000 francs to whomever could render the voltaic battery applicable, with economy, as a source of heat, light, power or chemical action, or in practical medicine.

LESSONS IN PRACTICAL ELECTRICITY

INDUCTANCE OF ALTERNATING CURRENT LINES.

As every circuit carrying current must be closed, a transmission or other line is simply a loop which, as in the case of the coils heretofore considered, must be filled or emptied of lines of force every time a current is set up in it or dies out. In the case of a metallic circuit, the area of the loop, of course, is the product of the length of the line by the distance apart of the wires. In the case of an earth return circuit, the effective area is, approximately, the length of the line by *twice the height* of the line above the ground.

Referring to Fig. 1, Biot and Savart early in the history of electrical science experimentally showed that if a current flows through a long straight wire, the force that will be exerted on unit pole at a point outside the wire is numerically expressed by twice the value of the current, c, divided by the distance from the wire to the point, or

$$F = \frac{2\,c}{r}$$

By definition, the force at any point is also measured by the density of the lines of force at that point, so that at a distance, r, from a wire carrying a current, c, the density of the lines will also be expressed by

$$\frac{2\,c}{r}$$

—of course, natural or *C. G. S.* units being used. Reduced to amperes and inches, this formula becomes

$$\frac{8\,C.}{r}$$

The above principle enables us to see why the distance apart of line wires affects the line inductance. Suppose, for example, we have a line current of 10 amperes; then the density of lines at a distance of 1 in. from the wire will be

$$\frac{80}{1} = 80$$

or at the rate of 80 lines per square inch; at 4 ins, 20; at 8 ins. 10; at 20 ins. 4 etc. Now, if the wires are only 4 ins. apart, the area will only contain the lines of force up to a density of 80 lines per square inch, all of those beyond having no effect on the inductance as they do not cut in and out of the loop as their number changes with change of current.

In considering inductance of lines, however, what is desired to be known is the total number of lines enclosed rather than the intensity at any given point, and this is given, in lines of force per foot of wire, by the formula, $N = 15.24 + 140.4,\ k$, where k is a value that may be found for a given case in Table I. In this table, the numbers 10, 20, etc., are the ratios of the distance apart of the wires, to the diameters of the wires. For example, the diameter (d) of a No. 1 wire, *B. & S.*, is .3 in. and if the wires are 12 ins. apart $\frac{D}{d} = 40$, and the corresponding value of k will be found in the table to be 1.9.

TABLE I.

VALUES OF k.

$\frac{D}{d}$	k	$\frac{D}{d}$	k	$\frac{D}{d}$	k
10	1.3	50	2	120	2.38
20	1.6	60	2.08	150	2.47
30	1.77	70	2.14	180	2.55
40	1.9	80	2.2	240	2.68

Now suppose we have a loop of No. 3 wire and wish to find its self inductance per foot—that is, the number of lines of force which it will contain when unit current is being carried, which number will also numerically express the E. M. F. that will be generated if this current dies out uniformly in one second.

This latter consequence is due to the fact that when the current dies out in one second, all of the lines of force will have passed out of the loop; since they all pass out in one second, and in doing so cut through the wires of the loop, an E. M. F. will be generated, expressed in the natural or C. G. S. system of units, by the number of cutting lines.

If the wires are 3 ins. apart, $\frac{D}{d} = 3 \div .3 = 10$ and $k = 1.3$. The inductance per foot, will, therefore, be $15.24 + 140.4 \times 1.3 = 49.65$ units, and therefore 197 units of inductive E. M. F. will be generated, which E. M. F. will, of course, be opposite to the line or impressed E. M. F.; if the lines are 6 ins. apart this becomes 224, and 266, 308 and 376 for 12 ins., 24 ins. and 6 ft., respectively. It will thus be seen that while the growth of inductance becomes smaller as the distance increases, yet the difference for lines 3½ ins. and, say, 12 ins. apart is quite marked.

The above formula expresses the *self*-inductance or coefficient of self-induction of a line, being based upon unit current and time, and uniform rate of cutting. If the rate of cutting is not uniform, and all of the lines are not emptied out in one second, a factor must be introduced to take account of this.

Without entering into this latter problem, the following formula is given for the inductive E. M. E. of alternating currents, of sine wave form, in which E' is the inductive E. M. F. in volts per thousand feet of wire, C the current in amperes, and n the frequency (twice the alternations per second), k having the same value as before:

$$E' = \frac{n\,C\,(.9575 + 8.82\ k)}{10000} \quad (2)$$

To show the application of the formula we will apply it to two circuits: First, a transmission line 5000 ft. long of No. 0 wire (100,000 ft. of wire), over which a current of 70 amperes at 1000 volts and a frequency of 60, is passing; and second, a circuit of the same length, but of No. 8 wire, the current being 10 amperes and of the same frequency and voltage as above.

From a wire table we find that the resistance of 10,000 ft. of No. 0 wire is 1 ohm and that the resistance of the same length of No. 8 wire is 7 ohms. The drop (CR) in each wire is, therefore, the same or 70 volts, that is, 7 per cent. Suppose that the wires are 12 ins. apart; since the diameter of No. 0 wire is .34 in., and that of No. 8 wire is .165 in., the values of $\frac{D}{d}$ for the two wires are 35 and 74, respectively. Interpolating in Table I, we find that the corresponding values of k are about 1.84 and 2.16, respectively.

Returning now to formula (2), from the above data we find the inductive drop on the No. 0 wire to be, in volts

$$E' = \frac{10 \times 60 \times 70\ (.9575 + 8.82 \times 1.84)}{10{,}000} = 72.51 \text{ volts.}$$

Similarly, the inductive drop of the No. 8 wire is 12 volts, or the two values are nearly in ratio to the current carried, that of the larger wire being somewhat less per ampere.

The combined effect on the line of the ohmic drop, or that due to the resistance of the wire, and of the inductive drop, or that due to the inductance of the wire, is not the arithmetical, but the vector, sum of these two quantities. That is, the total loss of voltage is not $E + E'$, where E is the resistance drop, but $\sqrt{E^2 + E'^2}$. In the case of the No. 0 wire, $E = 70$, $E' = 72.51$, while for the No. 8 wire the quantities are 70 and 12, respectively. Consequently, the total effective drops in the two lines are

$$\sqrt{70^2 + 72.51^2} \text{ and } \sqrt{70^2 + 12^2}$$

or 100.5 and 71.02, respectively.

It will be seen that while the inductive drop in the smaller wire is negligible, this is far from being true with respect to the No. 0 wire, the drop on which is increased from 7 per cent. to over 10 per cent. by the use of an alternating current having a frequency of 60 periods per second. As the increase of the inductive drop is proportional to the frequency, for the usual lighting periodicity of 133, the inductive drop would become 161.2 volts for the larger wire, and 26.6 volts for the smaller one; combining these quantities with the resistances as before, we have 175.7 volts and 74.8 volts. Here again, while the drop on the large wire is increased to over 17 per cent., the increase for the small wire is negligible, being less than one-half of 1 per cent.

The very large increase of drop in large wires carrying alternating currents is usually ascribed to the effect of the large wire itself. As will be seen above, this is only indirectly true, the larger currents carried by such wires being the direct causes of the increase. In fact, the inductance (inductive drop divided by the current) is actually decreased with increase of size of wire.

The drop due to inductance may be decreased to any desired extent by subdividing the wires. For example, as seven No. 8 wires are about the equivalent of one No. 0, by using seven pairs of the former in parallel instead of one pair of the latter, the total line drop would be reduced to that calculated for the No. 7 wire, in which the part due to inductance is negligible. This follows from the fact that each pair of the smaller wires, if the different pairs were sufficiently separated, would be under exactly the same conditions as to inductive and ohmic drop as the single pair considered. The same effect would be produced by transposing the wires with respect to the different pairs. No reduction in drop, however, would occur by splitting only one of the wires, as in this case the conditions with respect to the cutting of lines of force would not be changed.

Of the two components of drop on alternating lines, for a given current that due to resistance will be decreased, of course, in direct proportion to any increase in the sectional area of the line, but the inductive drop will be affected to a much less extent. As an example, suppose in the case of a No. 0 wire and a periodicity of 133, we were to double the diameter of the wire, thereby reducing the resistance of the line to one-fourth ohm. The resistance drop ($C R$) would thus be reduced to $70 \times \frac{1}{4} = 17.5$ volts, while from formula (2) we find that the inductive drop would become 115.7 volts. That is, by quadrupling the section of the line the resistance drop is reduced 75 per cent., while the inductive drop is only reduced 27 per cent. and still remains larger than the original resistance drop. The effective drop in this case would be $\sqrt{17.5^2 + 115.7^2} = 117.1$. Thus by quadrupling the amount of copper, the effective drop is only reduced from 17.5 to 11.7 per cent., while with a continuous current the drop on the new conductors would only be $7 \div 4 = 1.75$ per cent. It is thus evident that, when inductive drop on an alternating current line becomes appreciable, the only practicable remedy is to split the conductors.

Letters on Practical Subjects

Insulation of Induction Coils.

Under the title "Insulation of Induction Coils," your correspondent, "Dielectric," points out, in your January issue, the difficulty of using solid paraffine, and the liability to air bubbles forming during its cooling and shrinkage. This is a very real difficulty and renders immersion in oil a preferable method. But the oil has the additional advantage of self-healing in case of puncture, which property no solid possesses. However, the air bubble porosity of the solid paraffine can be obviated by subjecting the mass to considerable pressure while cooling and solidifying and ensuring a very gradual cooling of the same. In this case the receptacle should be filled with the hot liquid paraffine and plenty of time allowed for the escape of gas bubbles before cooling under pressure.

ELIHU THOMSON.

Lynn, Mass.

An Induction Coil that Exploded.

An accident occurred a short time ago to a paraffine induction coil, which was sufficiently unique as well as ludicrous to be worthy of relation.

The induction coil had just been completed and its performance was all that could be desired, when a prospective buyer of apparatus appeared on the scene. On being shown the new coil and its performance he declared himself suspicious of "these electric fixins," for "thar's no tellin' when they mought blow up." The builders of the coil in their superior knowledge of its construction laboriously explained that such was an impossibility, and I think I may safely say that their opinion would be confirmed by any electrical expert. Nevertheless while the explanation of the impossibility of such a catastrophe was at its height, the coil *did* blow up with a rattling report, and the whole construction was shattered. The utter amazement of the electrical experts and the triumphant delight of the rural delegate at this unexpected demonstration of his asseverations can better be imagined than described, and for the dignity of electrical science we will leave this phase of the picture and pass to the cause of the accident.

On examination of the ruins, the center of the explosion seemed to be a large cavity or blow hole in the paraffine, and as this cavity was the size of an egg or larger, the analysis was easy. This hole had become filled with a mixture of hydrocarbon vapor and air which, as is well known, is highly explosive. A spark penetrating the chamber did the rest.

Of course, all explanations were lost on the rural gentleman, whose triumph overshadowed all else, and he left declaring that electrical engineers didn't know as much about electricity as they thought they did, and, as for the engineers themselves, they began to be of the same opinion.

DIELECTRIC.

New York, N. Y.

Quick Destruction of an Electric Light Plant.

On Sunday morning January 31, the Illuminating Heat & Power Company's plant, of Scranton, was totally destroyed by fire, which originated in the cupola and was probably caused by the crossing of some wires. In fifteen minutes from the time the alarm was sounded, the whole building was in flames, and in twenty minutes the roof fell in. The machines were all left

running, the engineers and firemen only having time to blow off the boilers and start the pumps to fill them with water.

The company supplied about 8000 incandescent and 300 arc lights, and had a large motor service. The other company, operating in Scranton—the Suburban Electric Light Company—which uses the alternating system, has about the same capacity in lights, and with the help of a few isolated plants is now carrying most of the lights and supplying the motor service of the plant destroyed.

EDWARD N. ANKETELL.

Scranton, Pa.

Discharge of Electric Railway Circuits.

Prof. W. M. Stine, in his article on "Safety Devices for Electrical Circuits," read before the recent meeting of the Northestern Electrical Association, makes the following statement: "Another matter which demands fuller treatment than can be here given to it is the protection of large electromagnets against high E. M. Fs. of self-induction. Transformers and the fields and armatures of dynamos and motors are here referred to. Due provision should be made for absorbing circuits across the terminals of all electromagnets. The simplest form which this protection can assume is a circuit of one or more incandescent lamps placed across the terminals. If the exciting currents in such magnets be suddenly interrupted, the incandescent lamps will absorb the energy which otherwise would spend itself in piercing and burning out the insulation."

Would not the above precaution apply as well to the feeders of electric railway circuits? The sudden rupture of such feeder circuits by the opening of a circuit breaker is, under some circumstances, equivalent to the rapid opening of a circuit containing many motor armatures and fields. Therefore, is it not reasonable to suppose that some of the troubles with motor and feeder cable insulating might occur in just this way? Considering quick action to be the desirable feature in a circuit breaker (development being in that direction), as the time occupied in opening decreases, the danger from the high E. M. F. of self-induction increases, and the necessity for some protective device suggests itself.

A circuit breaker with carbon followers might be made to maintain an arc between the carbon contacts for a time sufficient to discharge the circuit; or, that method failing, others could be adopted which would cause the magnetic energy to be gradually dissipated.

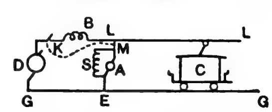
As it frequently happeus that the breaker opens because of there being too many cars on that particular feeder section, the disastrous effect may be materially heightened.

S. MOUNTAIN.

Philadelphia, Pa.

A Shunt Motor on a Railway Circuit.

The following is an experience which occurred to the writer and which probably has occurred, or may occur, to others' observation. In the figure, D is a street railway generator supplying power to cars, at C,



by means of the trolley wire, L L, and ground return, G G. B is the usual circuit breaker, and K the line switch. S and A are the fields and armature, respectively, of a shunt motor used to run the repair shop adjacent to the power station, and the shunt motor is connected to the trolley and ground as shown at L G, in the figure.

Whenever the circuit breaker, B, would go out, which was not infrequently, the shunt motor would throw its belt, thus delaying shop work until replaced, only per-

haps to go off several times more in course of a day. Upon replacing the shunt motor by a series motor, the trouble ceased.

The explanation of this peculiar behavior is this: As long as the circuit is closed, D feeds the line and runs $S\ A$ as a motor. As soon as B opens, D becomes idle so far as the line is concerned, and $S\ A$, having no line voltage to choke back its counter E. M. F., immediately (in virtue of the momentum) becomes a generator, sends current through the trolley, cars, ground and itself (M-L-L-C-G-E-$\frac{a}{s}$-M), overloads and throws its belt. This action takes place before the motormen can "throw the power off" the cars (i. e., throw the controller handle to the "off" position), some of which are probably running on notches without resistance in. In this case or in the case of a ground on the line or car motor, there is a dead short circuit and the belt goes off. Substituting a series motor obviates the trouble, because a series machine running as a motor will not generate unless either field or armature connections or the direction of rotation is reversed, whereas a shunt machine runs in the same direction, for given connections, whether as motor or generator.

In the above particular case, it would have been unnecessary to discard the shunt motor had its trolley side been connected below the circuit breaker as indicated by the dotted line, $M\ K$. This method would be cheaper and simpler, but would be impracticable where the power house and motor are several miles apart, unless an extra wire, $M\ K$, were run back, and possibly this might be impracticable. S. L. CLEVELAND.

Buffalo, N. Y.

Some Problems in Alternating Current Working.

Will one of your readers inform me as to whether the wave form of alternate current curves makes any difference in the operation of two alternators in multiple? For instance, could an alternator giving a peaked wave be operated as successfully with one giving a flat topped wave as if each machine gave the same wave form as well as frequency?

I would also like to know a good graphical method of plotting the form of the resultant wave, having given the two different waves that are to feed the same line together.

If two machines of the same capacity giving the same frequency and voltage, but one having a smooth body armature and the other a toothed armature, were run in multiple how would the load divide? Would the greater self induction of the toothed armature enter as a factor? If the peaked wave is an objection, would the smoother sine wave of the smooth body armature have a beneficial effect upon it?

I would also like to know if, when compound alternators are run in multiple, it is necessary to make any connection equivalent to the ordinary equalizer connections on direct current machines. If so, how is this connection made? On what side of the current rectifier? Could you not secure and publish a diagram? GRADUATE.

Chicago, Ill.

ELECTRICAL CATECHISM

95. Explain the elementary principles of the transformer.

The fundamental principle of the transformer is practically the same as that of a dynamo, namely, an electromotive force is set up by any change in the number of lines of force enclosed by a threading through a circuit. The alternating current through one coil causes the iron core to be magnetized, demagnetized and remagnetized in the opposite direction, corresponding to every cycle of change in the magnetizing current. This changing magnetization induces corresponding electro-motive forces in every coil surrounding the iron core, the electromotive force in each coil being proportional to the rate of change of magnetization and also to the number of turns of wire in the coil. There is thus an induced E. M. F. in the magnetizing coil as well as in the other. In the case of the magnetizing coil the induced E. M. F. is nearly equal to the E. M. F. that causes the magnetizing current, and is almost directly opposed to it, being known as a counter E. M. F. or C. E. M. F. Since the induced E. M. F. is proportional to the number of turns of wire about the iron cores it follows that the electro-motive forces or voltages in the two coils have the same ratios as the number of turns in their respective coils. For example, if one coil has ninety turns, while the other has only nine, the voltage in the first coil is ten times that in the second. By similar reasoning it may be shown, as experience proves, that the currents bear the inverse of the same ratio. For example, if one coil carries 1 ampere at 100 volts, the other would give about 10 amperes at 10 volts, the product of amperes by volts in both coils being nearly equal. As a matter of fact there is a loss, which may vary from one to as high as fifteen per cent.

96. For what changes of voltage are transformers commonly made?

Transformers for incandescent lighting are usually made for 1000 or 2000 volts on the primary or fine-wire side and for 50, 110 or 220 volts on the secondary or coarse-wire side. Transformers for alternating arc lamps usually give about 30 volts on the lamp side while the fine-wire circuit is wound for primary voltage of 100, 1000 or 2000 volts. For long distance transmission a variety of ratios are used, 1000 or 2000 volts or sometimes 5000 or 6000 volts being delivered by the generator and then raised to voltages ranging from 5000 to 22000. Transformers for welding or heating give heavy currents at low voltages; one used for welding rails of street railway track, being designed to reduce from 350 volts to about 4 volts, at which voltage current passes sufficiently powerful to heat a portion of a street railway rail to the welding point in a very short time.

97. What are the sizes of ordinary transformers?

These range from small voltmeter transformers, about 4 ins. $\times$ 6 ins. in size, to the 1000-KW transformers at Niagara Falls, which are 8 ft. high and weigh 25,000 lbs. each. Transformers may be had in all sizes, from 5-light capacity up to as large as 1000 lights or more.

98. What is meant by "step-up" and "step-down" transformers?

A step-up transformer is one used for changing the voltage from low to high. A step-down transformer changes the voltage from high to low. There is no difference between the two transformers except in their use.

99. How can the same transformer be used either to raise or to lower the secondary voltage?

The ratio between the voltages of the two coils depends upon the ratio between the number of turns of wire on the two coils. Since both coils surround the same core it follows from the elementary principles laid down before (see No. 95) that if either coil is connected to a suitable source of supply it will magnetize the core and induce electromotive force in the other coil. The secondary voltage will be higher or lower than the primary, according to the ratio of the turns of wire in the two coils.

100. What prevents an enormous current from passing through the primary coil and burning it out?

The current is opposed by the counter-electromotive force mentioned above in No. 95. The small alternating current that passes through the primary coil magnetizes the iron core, first in one direction and then in the other. This rapid magnetization and demagnetization means that the number of magnetic lines of force threading through the iron core inside of the coils is continually changing. Looked at from a slightly different standpoint, it means that lines of magnetic force are continually crossing the coils, or that the coils are continually cutting the lines of force. The result is the same viewed from either standpoint, the changing magnetization of the iron core causing electromotive forces in the coils surrounding the iron. The electromotive forces thus induced in the secondary coil cause current to flow in the secondary circuit. Likewise, the electromotive forces similarly induced in the primary coil tend to send current through the primary circuit in opposition to the original current. Thus, the electromotive force induced in the primary coil acts as a counter-electromotive force opposing the impressed E. M. F. or voltage on the primary circuit, and so holding back the current.

101. Does the primary coil of a transformer always take the same current, or does the current vary according to the current taken from the secondary?

The current through the primary is almost exactly proportional to that through the secondary. For example, a 50-light or 2500-watt transformer for reducing from 1000 to 100 volts takes about one-fourth of an ampere (0.23) when the secondary circuit is open; this increases to about three amperes when the secondary circuit supplies forty lamps.

Queries and Answers

What percentage of loss do central stations generally allow in inside incandescent wiring? G. K.

Two per cent. maximum.

In building a rheostat, which way should I make the handle to turn in cutting out resistance? I. N. D.

Clockwise with respect to front of switchboard.

What kind of iron wire and of what diameter should be used for the core of the induction coil described in the January number? J. B.

The softest iron wire that can be procured, and the finer, the better.

How can I make a fuse-block and plug? F.A.B.

Owing to the cheapness of this fitting, the simplest way is to buy one as a sample. You can probably buy half a dozen as cheaply as you can make one.

What kind of current does an induction coil give? F. F. P.

An alternating current, but with the E. M. F. pulsation corresponding to the break of the primary circuit much higher than the one corresponding to the make.

1°. Will it harm a Geissler tube if an undue amount of current is applied to it? 2°. Can a 6-in. tube be connected with safety on a 3-in. induction coil? R. W. B.

1°. An undue amount of current will heat the terminals, thereby injuring the tube. 2°. Yes.

Where several shunt machines are connected to a three-wire switchboard, how may one be reversed in cutting it out? A. J. C.

By slowing it down or weakening the field before its armature is disconnected from the bus-bars. See Crocker & Wheeler's "Practical Management of Dynamos and Motors."

Why does a simple alternator drop its E. M. F. after running at full load for a while? M. E. C.

It is difficult to say without more detailed information; if it is a modern machine it may be due to overload, which causes excessive armature reaction and weakens the field. This could happen without overheating.

What is the resistance of a rod of graphite one inch in diameter and one foot long? T. L.

According to one constant given by Everett, the resistance would be $\frac{1}{4}$ ohm, and according to another, $\frac{1}{10}$ ohm. The resistance of such materials varies widely, owing to impurities and variation in density.

1°. How can I make a battery gauge to fit a No. 16 watch case? 2°. How can I make a pair of strong magnets to work from one or two cells of dry battery? H. H. P.

1°. Make a galvanometer coil to fit the watch case, using about 50 ft. of No. 30 wire. For storage cells a finer wire and more of it would have to be used. 2°. See answer to H. H. P.

1°. Could a solid core be used instead of one of soft iron for an induction coil? 2°. Should the core be insulated before the primary wire is wound on? L. E. R.

1°. A solid core is unsuitable on account of the eddy currents that would be set up in it. 2°. As a matter of precaution, yes, though the insulation of the primary wire is sufficient for the low primary voltage.

1°. What is the conductivity of coal gas. 2°. Will the pull on the armature of a magnet be the same in vacuo as in air? 3°. Has the core of an induction coil the same number of lines of force with closed and open secondary.

1°. All gases are non-conductors of electricity. 2°. Yes. 3°. The magnetic flux when the secondary is closed is, under normal conditions, practically the same as on open circuit.

1°. Are electro-plating dynamos shunt or series wound? 2° What is the ratio of armature to field resistance in such machines? C. J.

1°. Electro-plating dynamos are shunt wound. 2°. There is no definite ratio. Having calculated or experimentally determined the field ampere-turns of any dynamo, the resistance will depend upon what electrical efficiency the machine is to have; if this is to be large, the resistance will be large and *vice versa*, irrespective of the resistance of the armature.

What size wire, and how many turns and layers must I use to wind a magnet strong enough to raise 2 or 3 lbs., to be connected to a 110-volt circuit, either direct or through a resistance? A. J. S.

Almost any size of wire and number of turns on a half-inch piece of soft iron bent horseshoe shape will do to lift 2 or 3 lbs. Connect to the circuit through an incandescent lamp, or several in parallel, as it would be absurd to go to the expense of putting on expensive copper resistance in order to connect direct to a 110-volt circuit.

1°. Why are the frames of belt-driven alternators insulated from the ground and those of direct-driven machines not? 2°. Would not a ground on either side of the line form a short-circuit? 3°. What causes the voltage on the line to rise so high when a live arc circuit is opened? K.

1°. Because it is practicable to insulate a separate machine, but not one coupled metallically to the engine. 2°. Not unless the armature winding were grounded on the core. 3°. The discharge or "kick" from the field magnet of the dynamo is due to self-induction. See "Lessons" in January number.

1°. What is the best method of charging one or several storage batteries from a 110-volt circuit? 2°. What is the best book on storage batteries? G. R.

1°. Connect the batteries in series with twice as many 16-CP incandescent lamps in parallel as the charging ampere rate of the battery, or as many 32-CP lamps as the charging amperes. The neatest way is to disconnect one of the fuses of a lamp circuit of the proper ampere capacity, and then put the cells, arranged in parallel, in series with that leg of the circuit. The reduction in the candle power of the lamps on the circuit will be so small as to cause no inconvenience, and thus the battery charge will cost nothing. 2°. Salomon's "Electric Light Installations—The Management of Accumulators," ($1.50).

How can I make a strong lifting magnet to work from one or two cells of dry battery? H. H. P.

First, determine the winding. For maximum lifting power the resistance of both coils (on the two legs of a horseshoe magnet) should be equal to the internal resistance of the cells employed. This internal resistance may be approximately found by short-circuiting a cell through an ammeter, and then dividing the E. M. F. of the cell by the ampere reading. Suppose this should be done with a dry cell and the reading found to be $4\frac{1}{2}$ volts; as the E. M. F. is about $1\frac{1}{2}$ volts, the internal resistance of each cell is, therefore, $\frac{1}{3}$ ohm, and of two cells $\frac{2}{3}$ ohm. If No. 20 bell wire is at hand, this will correspond to about 30 ft., which may be wound on a piece of round soft iron a foot long bent into the form of a horseshoe. Dry cells are not suitable for this purpose unless the current is to be on only for an instant at intervals.

Can a Wimshurst machine be made to work without sectors? G. H.

A Wimshurst machine without sectors can be made and used with success, but it requires an initial charge to start it. This charge may be applied by turning the machine and, while it is in motion, charging one of the terminals strongly with some outside source of electricity of suitable potential. As James Wimshurst himself has said, "The less of the sectors the better, but the smaller their area the less reliable the machine." The sectors of the machine described in the November number of the American Electrician can be reduced in length one-half, and a like amount in diameter with beneficial results and the machine will still be fairly reliable. But with no sectors at all, the machine will operate when it chooses, according to the weather conditions, even if it be properly charged.

How can I make a simple storage battery for experimental purposes? S. T. B.

If some cast-off battery grids cannot be procured for refilling, proceed as follows: Make a lead frame, say, 4 ins. square, by bending a piece of strip lead $\frac{1}{4}$ in. × $\frac{1}{8}$ in. and 20 ins. long, about a board of the same dimensions, letting the two ends project above one corner to serve as a lug, which solder together. Get some thin lead and cut it into strips of a width equal to the thickness of the frame. Corrugate half of the strips and build up within the frame a cellular structure, using alternately a plain and a corrugated strip, and solder the strips to the sides of the frames, using a solder containing much more lead than tin and employing rosin as a flux. Make five plates like the above, two of which will be positives and three negatives. Fill the cells of the positive plates with a paste made of the purest red lead obtainable, mixed with one part of sulphuric acid to ten parts of water; fill the negative plates with a paste similarly made of litharge. Solder to one lead strip the two positive lugs and to another the three negative lugs, the plates being kept separated $\frac{1}{4}$ in. by rubber or fibre strips. The electrolyte should consist of one part of sulphuric acid to four parts of water. This cell will have a capacity of 4 or 5 ampere-hours per pound of plate, and should be formed by being charged until the electrolyte violently "boils", with a current of $2\frac{1}{2}$ amperes, which may be obtained by placing the cell (or several of them) in series on a 110-volt electric light circuit, with five 16-CP lamps. After the first "boiling" let the plates rest for several hours and then pass another charge through them. Be sure to connect the red lead plate to the positive side of the circuit. This may be determined by passing current from the charging circuit (with a lamp in series in the case of a lighting circuit), through two small strips of lead in a glass containing dilute sulphuric acid; the strip that turns brown is connected to the positive side of the circuit.

New Apparatus and Appliances.

STATIC GROUND DETECTOR.

This ground detector, illustrated in the accompanying engravings, is essentially a differential static voltmeter made up of four vanes fixed to a base, and a movable vane carrying an index or pointer. The movable vane is made of sheet aluminum mounted of a shaft and held centrally, by two jeweled bearings, between the fixed metal vanes. The diagonally opposite fixed vanes are connected in pairs, and each pair is statically charged from one pole of some source of electrical supply. The movable vane, which is connected to "earth," is inductively acted upon by each pair of fixed vanes, so that the stress produced by each is equal but opposite. The movable vane in consequence takes a position equally between the fixed vanes, which position is, theoretically, the same whether the instrument is charged or not, and is the position of "no ground," the pointer pointing to the zero of the scale.

FIG. 1.—STATIC GROUND DETECTOR.

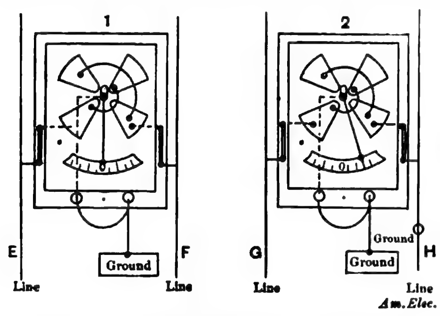


FIG. 2.—STATIC GROUND DETECTOR.

If one pair of fixed vanes and the movable vane are electrically connected, they are charged of like character from one pole of the source, the other fixed vanes being charged of opposite character from the other pole. The action of the similarly charged vanes is to repel the movable vane, while the action of the other fixed vanes is to attract it. The two forces acting in the same direction, the movable vane takes a position entirely within the oppositely charged vanes, the pointer deflecting to the side of the similarly charged vanes, and pointing to the position of "ground" for that side.

The static ground detectors are made in three types. One of these is for use on any two-wire or four-wire circuits of any E. M. Fs. over 500 volts and under 5000 volts, and for three-wire, three-phased circuits of the same voltages. Another is for E. M. Fs. of 5000 volts and higher, and a third for use only on three-wire, two-phased circuits and for E. M. Fs. over 500 volts and under 3000 volts.

The general appearance of all instruments is the same, differing only in details.

There is no connection through any of the instruments between the line wires or between either of the wires and earth. It is not necessary to first introduce a temporary ground on the line in order to test for an existing ground, the characteristic defect of old forms of ground detectors. This feature is of great importance as it insures greater safety to linemen and lessens the possibility of short circuits in the instrument itself. The instrument consumes no energy and may be left continuously in circuit, indicating grounds as soon as they occur. An instrument for each circuit may therefore be used to great advantage.

The instruments are mounted on a separate base or directly on the switchboard; they are entirely covered by a case of plate glass and all parts are perfectly insulated from the operator.

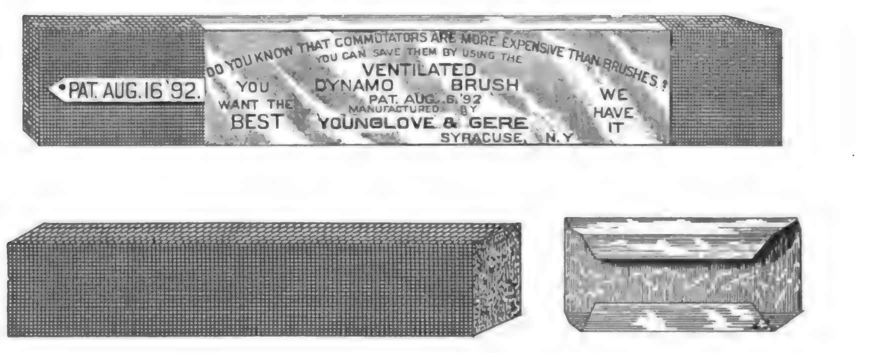
Type B, which is for E. M. Fs. of 5000 volts or more, is shown connected in Fig. 2. The line wires are connected to a primary set of vanes which are behind the visible fixed vanes and separated from them by large plaques of hard rubber and mica. The visible fixed vanes are charged inductively from the primary vanes instead of directly from the lines. This type of instrument is mounted on a mahogany base in which are embedded the primary vanes and the mica plaques, which construction secures perfect insulation for very high voltages.

The third type is similar in construction and in appearance to the others, differing only in having the vanes connected to the outside wires partially cut away. This is claimed to be the only ground detector that will work properly on a three-wire, two-phased circuit, all others always indicating "ground" on the middle wire whether there is one or not, on account of the unequal E. M. Fs. between the wires. The relative potential of the middle wire of a two-phased circuit is dependent upon the capacity with respect to the earth and this, in turn, upon the extent of the lines and their distance from the earth. For very short or very long lines, therefore, special adjustment may be necessary in order to make the instrument indicate correctly, but generally the standard instrument will meet all requirements and is furnished unless special instructions are given. Fuse wire used for all these ground detectors is the well-known platinum-silver wire used in Cardew voltmeters. The ordinary lead fuse should never be used.

The above instruments are made by the Stanley Electric Manufacturing Company, Pittsfield, Mass.

WOVEN-WIRE DYNAMO BRUSH.

The dynamo brush shown in the accompanying illustration embraces several features of interest. It is of the woven-wire, ventilated type, and has an adjustable shield which stiffens the brush and keeps it in perfect form, preventing the material from spreading without the use of tubes or plates. The shield also obviates waste, as by its means all stubs can be used up.



WOVEN-WIRE DYNAMO BRUSH.

The brush shown is made by Younglove & Gere, Syracuse, N. Y.

CEILING ROSETTE AND COVERED CUT-OUTS.

Among recent interior wiring fittings are several illustrated herewith, consisting of a ceiling rosette, a main line and a branch cut-out. The former, shown in Figs. 1, 2 and 3, has the cap secured to the case by means of the brass kidneys of the cap inter-

locking with the line contacts of the base. These are held in place and tightened by the round-head screws shown in the cap, to remove which it is only necessary to turn the screw, *A A*, a half turn and revolve the cover to the left. The fuse chambers are

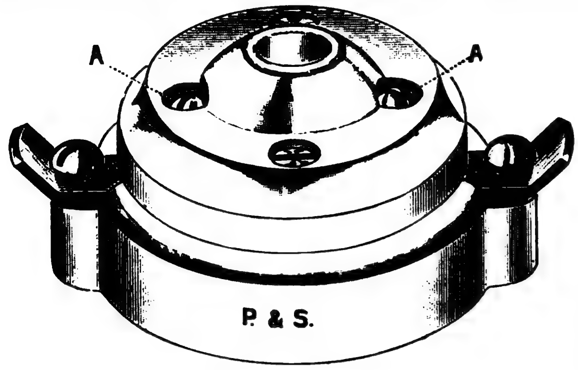


FIG. 1.

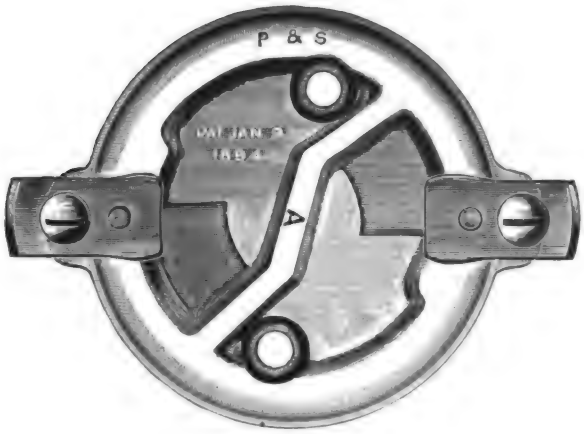


FIG. 2.

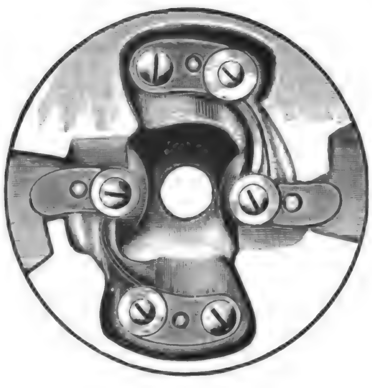


FIG. 3.

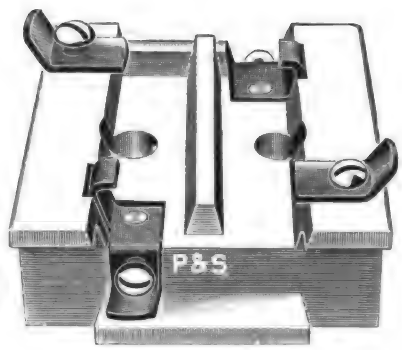


FIG. 4.

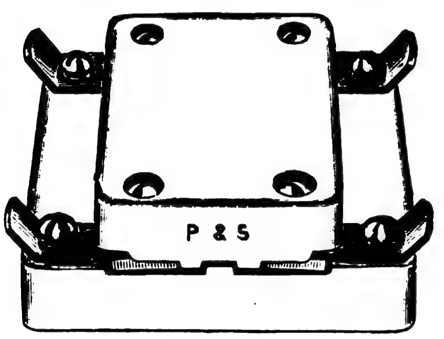


FIG. 5.

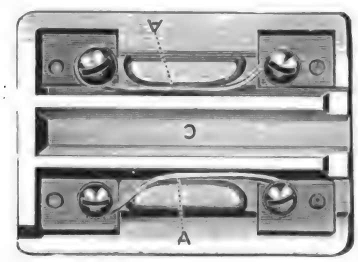


FIG. 6.

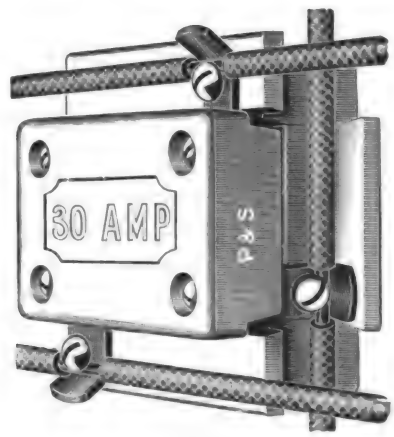


FIG. 7.

entirely separated from each other by the china rib, *A*, shown in Fig. 2. Either metal-tipped fuse links or ordinary fuse wires can be used.

Fig. 5 shows a main line cut-out, and Figs. 4 and 7 a branch cut-out, the cover of each being illustrated in Fig. 6. As will be seen in Fig. 6, there are separate channels for the fuses, and when the cover is on the base, these channels, as well as the fuse contacts, are separated by the projection on the base, which fits into the recess, *C*, of the cover. The fuse channels are just large enough to take the largest fuse for which the block is designed. To take off the cover it is simply necessary to loosen the round-head screws shown, a half turn and push the cover endwise.

LAG AND PIPE WRENCH.

The lag and pipe wrench shown in the accompanying engraving is a new departure in the line of an automatic wrench, and has a number of very desirable features. The movable jaw at the top causes it to tighten as the pressure on the handle is increased. It will not slip, takes hold and lets go suddenly, and is always ready. In the operation of this wrench there is no lost motion,

LAG AND PIPE WRENCH.

and no time is spent in adjusting. The wrench is made of drop forged steel, and the jaws of the best tool steel hardened and tempered, and can be replaced when necessary at a very little expense.

The Electric Appliance Company, Chicago, has undertaken to put this wrench, known as the "Martini," on the market, and has the exclusive sale for the same.

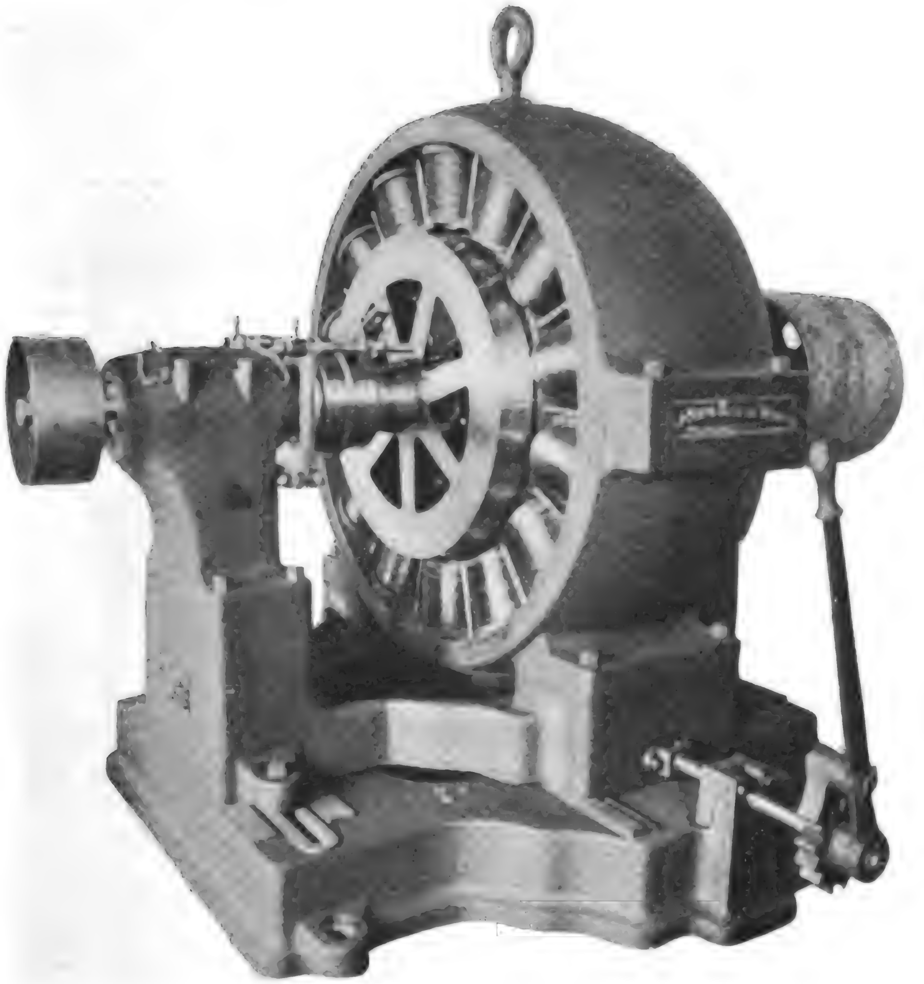
THE LA ROCHE ALTERNATORS.

We give herewith an illustration of the new La Roche alternating dynamo, which type of machine is built of from 1½ to 150 KW capacity. The field or pole ring of this machine is made in two sections, the upper half of which can be detached from the lower half, and the lower half in turn detached from the base, which is quite an advantage, especially in installing and transportation. The ring is mounted up on a cast-iron base which slides on a heavy cast-iron sub-base, a lever screw tightener enabling the base to be moved so that the belt can be tightened or loosened while the dynamo is at work. The bearings are of the well-known ball and socket type with an extra large oil reservoir together with oil gauges.

The armature of this machine is a special feature, being of the toothed or iron clad type. All wires are imbedded in the interior of the armatures, not being exposed to view or injury. The armature coil is built up of charcoal-iron sheets and mounted upon two bronze spiders keyed upon the armature shaft. These machines are insulated entirely by mica, and are, in fact, fire-proof. The connection of the coils and winding is so arranged that a difference in the E. M. F. between the first and the last coil is only equal to the E. M. F. generated in one coil, thereby insuring the armature insulation against undue strain. The ends of the armatures are covered with a heavy bronze shield handsomely designed and polished, which allows of sufficient ventilation. The collector rings are tempered, and are of the skeleton type; the construction is such that the rings can be taken off without removing the armature or frame.

The brush holders are made of brass, and controlled by an adjustable spring, thus rendering readjustment simple. Though these machines regulate perfectly, no compensated winding nor commutators of any kind are used with them. The regulation is electrically accomplished without the means of any outside contrivance. The makers of the machines state that in one

plant recently installed, consisting of two 150-KW machines, an overload of 50 per cent. is being carried with no evil resulting,



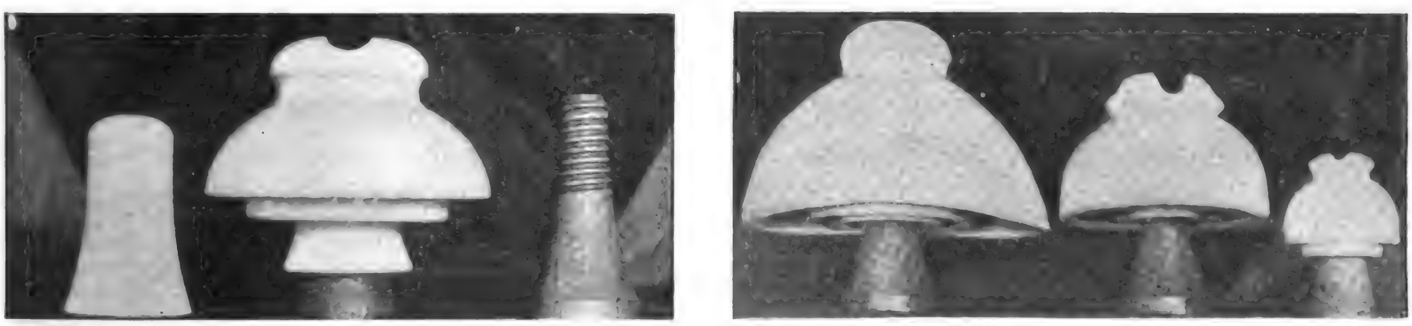
LA ROCHE ALTERNATOR.

the machines doing their work to the satisfaction of the purchasers.

The alternator above described is made by the Ideal Electric Corporation, Thirteenth and Hudson Streets, New York.

HIGH-POTENTIAL INSULATORS.

The accompanying engravings illustrate some of the latest types of Locke high-potential insulators, which have been designed to meet the requirements incident to the development of high-voltage transmission of



HIGH POTENTIAL INSULATORS.

power. The several forms shown have withstood tests when set in steel pins, of 70,000 volts for four hours without heating, breaking down or arcing.

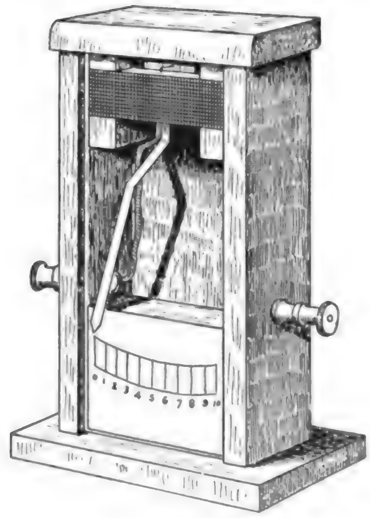
One special type of insulator, shown on the left, is composite in structure, consisting of an inner member of glass and an outer cap of porcelain; still another type is made with both portions of porcelain. By constructing these insulators with the inner member of glass, it is claimed that it is almost impossible to puncture or break down the insulation, glass offering the highest resistance against puncture, while porcelain has extremely high surface resistance. It is also claimed that by making insulators of two porcelain parts, each part may be made thinner and more easily, thus allowing for better vitrification throughout. The two parts are screwed or fused together and are very strong mechanically, as well as electrically.

The insulator on the left is designed to carry currents of from 20,000 to 40,000 volts, and those on the right for currents up to 25,000 volts. The former is used on the Niagara Falls and Buffalo transmission lines, and the latter on a number of circuits throughout the country of from 10,000 to 15,000 volts, on all of which the insulators are said to be giving perfect satisfaction. All of the above insulators are mounted on Locke steel pins with locust tips boiled in paraffine.

The insulators described are made by Fred. M. Locke, Victor, N. Y.

CHEAP AMMETERS AND VOLTMETERS.

Electrical measuring instruments are usually beyond the reach of amateurs and students owing to the high price at which they are sold, but the type illustrated herewith is



A SIMPLE AMMETER.

an exception to this statement, its cost being so low as to bring it within reach of the most slender purse. As will be seen from the illustration, the instrument consists of a neat wooden case with a glass face, behind which is the indicating mechanism. The latter is very simple, consisting of a coil at the top of the case, in which is a magnet that takes up a position corresponding to the amount of current passing. To the magnet is attached an aluminum pointer which plays over a calibrated scale, indicating amperes or volts, according to the winding of the coil used.

The simple and inexpensive instrument shown, is made by the Childs Manufacturing Company, 95 William Street, New York.

THE "BOSTON" TRANSFORMER.

The mechanical construction of the transformer shown in the accompanying illustration, while adhering to the Keystone shape, is very simple and durable. It is of the so-called removable coil type, and made both for dry and oil insulation. It is easy to put in place on account of the peculiar construction, but one hanger iron being used instead of two. The insulation is claimed to be as nearly perfect as can be made, the material used being especially prepared for this trans-

former. The coils are practically waterproof, and all terminals are brought out through porcelain bushings.

Believing that experience has shown that fuse boxes, under any conditions, should be placed on the transformer, the makers of

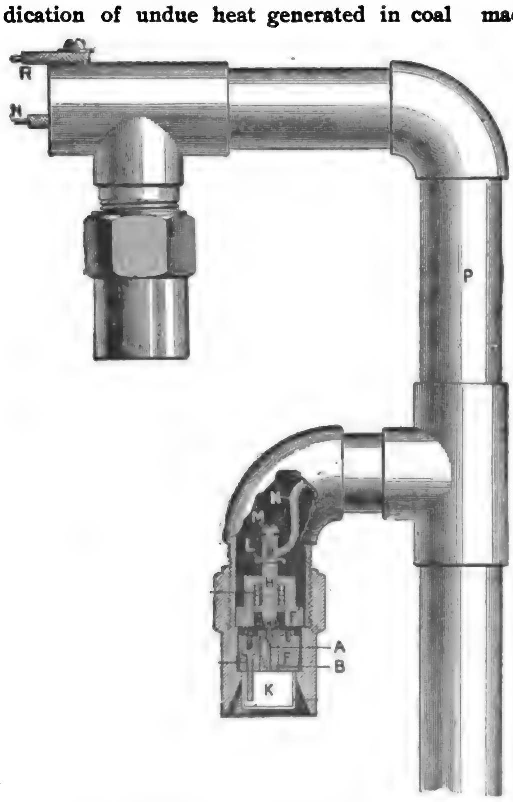
"BOSTON" TRANSFORMER.

this transformer have provided all of the later types with separate single-pole fuse boxes. The transformer has a high efficiency and close regulation, and a minimum core loss, and is guaranteed against burnouts from any cause, including lightning, for two years.

The transformer described is made by the Bibber-White Company, 49 Federal Street, Boston.

COAL-POCKET THERMOSTATS.

Among the most useful applications of the electric thermostat is its use in the indication of undue heat generated in coal



COAL-POCKET THERMOSTAT.

pockets, which has frequently resulted in disastrous fires. A form of this thermostat devised for the above purpose is shown in the accompanying illustration, in the lower part of which the device is shown in section. A negative wire, *R*, is attached at any point to the ¾-in. iron pipe encasing a positive No. 16 heavily-insulated wire, *N*. The thermostats are connected to the pipe, where desired, by ordinary pipe fittings, as shown. Should the surrounding temperature attain a dangerous elevation, mercury contained in the steel cup, *K*, by expanding into the small bore of a glass plug, *B*, makes a circuit through a steel needle, *A*, thereby ringing a bell situated where desired. As soon as the attendant hears the bell ringing, he moves a lever on a detector board connected with all of the thermostats in circuit. When the bell stops ringing he knows the lever is in contact with a segment corresponding to the thermostat closed, and thus the exact locality is indicated where spontaneous combustion has started, so that the trouble can be remedied at once.

The above thermostat is one of many forms made by the Electric Heat Alarm Company, 141 High Street, Boston, Mass.

TWO NEW THREE-PHASED FACTORY POWER PLANTS.

Among the latest applications of electric power are two factory plants recently installed by the General Electric Company, in both of which the three-phased system is used. One of these is at North Tonawanda, N. Y., in the bolt and nut works of Messrs. Plumb, Burdict & Bernard, and the other at Middletown, Conn., in the mammoth bicycle factory of the Keating Wheel Company.

While it is the intention to eventually obtain electric power at North Tonawanda from Niagara, a generating plant was installed in the works of Messrs. Plumb, Burdict & Bernard to answer present requirements. This is shown in Fig. 1, and con-

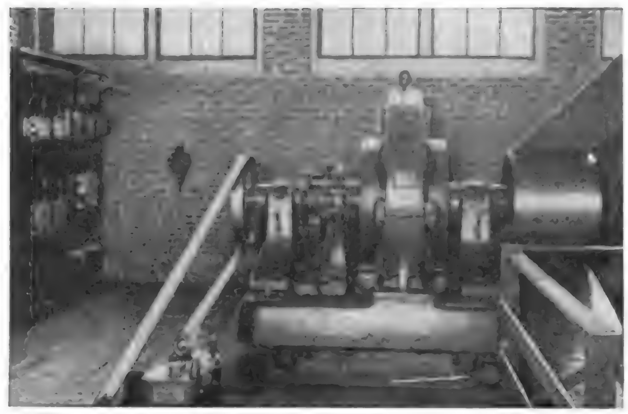


FIG. 1.—GENERATING PLANT.

sists of a 6-pole, 150-KW, 25-cycle, three-phased generator running at 500 r. p. m. and excited by a 3-KW, 125-volt bipolar machine. Sixteen three-phased induction motors are employed to drive the various machines, as follows: Five 25-HP motors in the forge shop; one 20-HP motor in the cold shop; one 20-HP motor in the machine shop; six 6-HP and three 20-HP motors in the threading shop.

In the forge shop (Fig. 2) four of the 20-HP motors drive shafting and one operates a blower. The driving motors themselves are set upon a platform above the shafting in the center of the shop, and are boxed in. The blower motor, directly connected to the blower, occupies a platform at the south end of the shop. The machinery driven by the motors in the forge shop are different sizes of bolt headers and nut punches and shearing machines for shearing the bolt lengths from the rod.

In the cold shop the pointing department

FIG. 2.—FORGE SHOP.

is operated by one 20-HP motor, set on the floor and belted to jackshafts and countershafts, as necessary. In the machine shop a 20-HP motor, also set upon the floor, is

used to drive a variety of tool-making machinery such as planers, milling drills, slotters, shapers, etc.

The threading and finishing shop is driven by six 6-HP motors, set on small platforms, and three 20-HP motors. The smaller motors and one 20-HP motor are used to drive the automatic and semi-automatic machines. For the former they are belted to jackshafts, from which belts are dropped to pulleys on a shaft running underneath the machinery. For the semi-automatic machinery, the pulley is on the level of the machines, and is belted to the jackshaft above.

The other 20-HP motors are set on the floor, and are belted to shafting on the op-

This is noticeable in the quality of the output.

The factory of the Keating Wheel Company at Middletown, Conn., will cover a floor space of no less than 168,250 sq. ft., and will be entirely operated by electric power, the three-phased system having been adopted.

The generating plant consists, at present, of a 16-pole, 250-KW, 60-cycle, three-phased, machine, running at 450 r. p. m., but another machine of the same capacity as well as a set of dynamos for lighting, will soon be added. The exciter is 4½-KW dynamo run from a pulley on the shaft of the generator.

The main building, 1000 ft. long, is one

FIG. 3.

posite sides of the shop. These serve to drive the heavy threading and tapping work not automatic, and some idea of the variety of machinery in these shops, and the work the motors are called upon to do, may be be gathered from the fact that the sizes of bolts made run from $\frac{3}{16}$ in. up to 1½ ins.

The advantages of electric drive are markedly noticeable in this plant. There are no separate engines for the individual shops, and no belt holes in the walls, as would have been the case had the steam driving plant been confined to an outside building. The wires come through three small porcelain-bushed holes in the wall of each shop. The central steam and generating station is confined to one room at present, and will, probably, shortly be entirely abolished. The motors in the forge shop occupy no space on the floor of the shop, and those in the other shops occupy either small space upon the floor or are erected on small platforms. They require no attention beyond the filling of oil wells, which is performed but once in six months. They are started by the throwing of a switch, and maintain a steady and constant speed under all conditions of load.

great hall, as shown in Fig. 3. The main shafting is about 800 ft. long and runs down a central aisle, being divided into three sections between each of which is a 50-HP induction motor of the inverted type. There are other shorter lines of shafting, which are about 350 ft. long, one on each side of the main shafting in the north part of the building. Still another line of shafting about 200 ft. long runs through the repair department. The motors driving the shafting in the main building are, as stated before, two of 50-HP, while the line of shafting running through the repair shop is driven by a 20-HP motor, secured to the ceiling of the first floor in the main building.

All of the motors are equipped with two pulleys on each end, so that four independent shafts can be driven from each motor. The extent of this shafting and the method of driving the motors can be gathered from Fig. 3, made from a photograph taken from one end of the main building. There are about 160 ft. of shafting on the other side of the far motor shown in the illustration; this will give some idea of the extent of the installation.

PERSONAL.

Mr. Max Helder, of Pittsburgh, Pa., was one of the prize winners in the international competition for plans and designs for an electric railway to the top of the Jungfrau, Switzerland. Sixteen prizes, amounting to $6000 were awarded, all but two of which went to Swiss and German engineers and manufacturers. The prize secured by Mr. Helder was for electric construction, the amount being 800 francs.

Mr. L. B. Stillwell has resigned his position of electrical engineer of the Westinghouse Electric & Manufacturing Company to accept an offer from the Niagara Power & Cataract Construction Company to act as its technical manager. Mr. Stillwell had charge for the Westinghouse Company, of the great work which it did at Niagara Falls, and is, therefore, peculiarly fitted for his new position. It is hoped that in the new position Mr. Stillwell will continue to have opportunities to exercise his qualities as an originator and designer, from which electrical engineering has so very largely benefited in the past.

OBITUARY.

Emil Dubois Reymond, the eminent German electro-therapeutist, died Dec. 26, at the age of 78 years. Dubois-Reymond was a descendent of a French revolutionary emigré, and like many other descendents of the French royalists who found refuge in Germany, had a violent dislike to France, which found expression in a speech delivered at the outbreak of the Franco-Prussian war, when he declared himself ashamed of the French blood that flowed in his veins. As a scientist he had high rank in many branches; in electricity. Aside from his contributions to the theory of electro-therapeutics, he was known as the inventor of an early form of galvanometer and of several pieces of electro-medical apparatus.

Mr. E. Carl Breithaupt, an electrical engineer, well known in Canada and the United States, died in Berlin, Ont., Jan. 27, at the age of thirty years. Mr. Breithaupt was a graduate of the Johns Hopkins electrical course, and in recent years was connected, in a professional and executive capacity, with the Berlin (Ont.) electric light and street railway companies. He was one of the principal spirits in the Canadian Electrical Association, in whose interests he incessantly labored, and was also a member of the American Institute of Electrical Engineers. Mr. Breithaupt possessed a charming personality, and his numerous friends in the United States and Canada feel that they have met in his death a severe personal loss.

Galileo Ferraris, the distinguished Italian scientist, died the beginning of the present month, at Rome. Prof. Ferraris, was best known for his discovery, in 1885, of the rotary field, upon which rests the principles of all polyphased apparatus, though his work in optics would alone insure him high rank in the annals of science. He was a true savant in the Europern acceptance of the word, devoting himself to research in the higher realms of science and leaving to others the practical application of the principles discovered. Both personally and intellectually he was extremely modest, and possessed of a personality of much charm. Professor Ferraris expressed himself to the writer as much pained at insinuations that had been made connecting the work of Tesla with respect to the rotary field with his own, and based upon the fact that Tesla's application for a patent was made two years after Ferraris' discovery. He accorded without reserve credit to Tesla for the independent discovery of the rotary field, and resented the use of his name to disparage one for whom he professed the highest admiration.

Mr. L. H. Hart, business manager of *Heating & Ventilation*, died at Brooklyn, N. Y., Jan. 25, from a heart affection after a short illness. Mr. Hart for several years was connected with the electrical press as Boston representative, and later, business manager, of the *Electrical World*. Owing to the possession of a most genial and sympathetic nature, Mr. Hart became one of the most popular members of the electrical fraternity, by whom remembrance of his engaging qualities will long be cherished. Upon leaving the *Electrical World*, Mr. Hart, in conjunction with Mr. H. M. Swetland, founded *Heating*

& Ventilation, which soon took high rank as a successful trade journal. It was mainly through the personal efforts of Mr. Hart that the now flourishing Institute of Heating & Ventilating Engineers was founded, of which body he was secretary. The estimation in which he was held by the members of the Institute is indicated by their action in raising a purse to provide for the future education of Mr. Hart's only child, a young son. Mr. Hart at one time was a member of the Connecticut legislature, and a few intimate friends were permitted to see a letter he possessed, written by Grover Cleveland when a candidate for the presidency in 1884, asking for Mr. Hart's active aid in the Connecticut campaign.

NEW BOOKS.

Ruhmkorff Induction Coils. By H. S. Norrie. New York: Spon & Chamberlain. Paper covers, 183 pages, 57 illustrations. Price 50 cents.

This little book describes the construction of an induction coil, and several forms of contact breakers and condensers. It also includes several chapters on experiments with such coils, a chapter each on gas-lighting by the series method, primary and secondary batteries, Tesla and Hertz effects and Röntgen rays and radiography. The book is well written and will be found instructive.

Elementary Lessons in Magnetism and Electricity. By W. Jerome Harrison. London and New York: Thomas Nelson & Sons. 283 pages 177 illustrations.

This little volume is intended as an introduction to the science of which it treats, being apparently intended as a teaching book for schools, and modeled after the requirements laid down by the British Education Department. The matter contained is elementary in character and limited in scope to teaching purposes not having in view applications of the knowledge imparted.

Physics for University Students. By Prof. Henry S. Carhart. 2 vol. Part I, Mechanics, Sound and Light. Part II, Heat, Electricity and Magnetism. Boston: Allyn and Bacon. Vol. I., 344 pages 152 illustrations. Vol. II., 446 pages, 224 illustrations.

To the student who has an elementary knowledge of algebra, trigonometry and the calculus, these two volumes will be found an excellent elementary course in the branches of which they treat. A knowledge of the calculus is not even actually necessary, as but few differential formulas appear in the book. Mathematics, in fact, enters to such a small extent, aside from formulas, that the volumes may be read with ease and profit by one not possessing mathematical knowledge—in this respect presenting a glaring contrast to some college text-books. Electricity and magnetism take up the greater part of the second volume, the treatment being such as to lay a foundation of general principles for a more advanced study of the science, either in its general or special aspects.

TRADE PUBLICATIONS.

Feed Water Heaters. The Stewart Heater Company, Buffalo, N. Y., in a 48-page catalogue describes the several types of feed-water heaters of its manufacture, the details of which are very plainly shown in a number of well-executed wood cuts. One of the types described is a sectional heater and eliminator made of a number of identical sections, thus enabling a heater to be enlarged at will by merely adding new sections.

Engine-Indicating Apparatus. The Buffalo Indicator Company, Buffalo, N. Y., describes in a recent circular a complete steam-indicating outfit of its manufacture, consisting of an indicator, reducing wheel, planimeter and indicator cocks, and also a simple instrument for determining the draft of a furnace or chimney. The various apparatus are well illustrated and their manner of operation clearly explained.

Flexible Conduit. The American Circular Loom Company, Station H, Boston, Mass., has issued a handsomely covered and printed catalogue, containing a large number of excellent half-tone views of important buildings and exteriors in which its flexible tubing has been used to encase electric wires. A partial list of constructions in which "Circular Loom" tubing is used covers ten closely printed pages, and includes fifteen yachts and two ferry boats.

Ammeters and Voltmeters. In a circular recently issued, ("No. 74") Charles Wirt, 1028 Filbert Street, Philadelphia, very thoroughly sets forth the advantages of the Queen-Wirt ammeters and voltmeters, and gives directions for their setting up. These instruments are now made for both portable and switchboard use, the latter modification having been made by Mr. Wirt since having acquired the sole right to the manufacture and sale of these instruments, of which he is the inventor.

Walker Monographs. Of the four latest technical circulars (Nos. 1026-9) issued by the Walker Company, one brings out the advantages of the Walker street railway motor with respect to lubrication and commutator construction, another describes the Norfolk & Ocean View electric passenger and freight railway, a third relates to the isolated plant installed in the new Waldorf Hotel—the largest isolated plant in the world—and a fourth illustrates in detail the Walker commutator, dynamo armature, and brush holder.

Wheatstone Bridges. Under the title of "Impartial Opinions from Practical Users," M. A. Knapp, Monadnock Building, Chicago, has issued a neat circular, giving facsimile reproductions of a number of letters of commendation from purchasers of the Wheatstone bridge of its manufacture. As indicated by the letter heads, those commending the instrument are qualified to judge as to its merits, and the verdict is that an accurate Wheatstone bridge may be made to sell at but a fraction of the price at which it is usually quoted.

Electrical Specialties. In an 84-page oblong pamphlet having the foregoing title, Pass & Seymour, of Syracuse, N. Y., illustrate and describe numerous kinds of wiring specialties of their manufacture, which together cover about every form of china fitting used in the electrical art. This firm has been particularly successful in making china insulations of difficult pattern, in this, as w ll as in some other respects, leading the world. The pamphlet, aside from its main purpose, will be found useful for technical reference on the branch to which it pertains.

Storage Batteries. The New York Accumulator & Electric Company, 150 Nassau Street, describes and illustrates in a catalogue just issued, the various forms of portable accumulators which it manufactures for medical and other purposes where portability is a necessary requirement. One of the forms is a combination of a storage battery and electric lamp, called a portable electric lantern. Among other specialties are electrically heated hot water bottles, electric belts, pads and foot warmers. It is scarcely necessary to add that the electric belts and pads are not nostrums of the kind that desecrated the electrical exhibit at the World's Fair, but means for applying electric heat to parts of the body.

Steam Traps. One of the oldest firms in the country manufacturing steam traps and other steam fittings is the Albany Steam Trap Company, of Albany, N. Y., and a recent catalogue bearing its imprint shows that, besides having mastered the mechanical art with which it is occupied, it has also profited by experience in the art of effectively presenting its goods to the public, as may be judged from the following extracts from the opening paragraphs of the catalogue: "We take it for granted that you are more or less bothered with circulars, letters and occasional visits of salesmen endeavoring to interest you in some one of the new, or so-called, steam traps for returning the water of condensation from steam heating coils, etc., back into the boiler automatically; and no doubt all are quite willing to guarantee most anything and everything for the particular trap they manufacture or desire to sell, and let you do some experimenting as well. We wish to call your attention to the fact that all of our steam traps and specialties are many years past the experimental stage. We did the experimenting years ago, and now offer you the benefit of our knowledge for the asking."

BUSINESS NEWS.

The Ball & Wood Company has removed its New York offices from 15 Cortlandt Street, to 120 Liberty Street, New York.

The Brooks-Follis Electric Company, of San Francisco, will hereafter supply the Coast trade with the well known dynamo brushes manufactured by Charles Wirt, of Philadelphia.

The Armorite Interior Conduit Company, Detroit, Mich., reports business as booming and that it has all it can do. The Armorite has issued a new price list making a considerable reduction from former prices.

Youngiove & Gere, of Syracuse, N. Y., report a growing demand for their dynamo brush from all over the country. The firm is much gratified with the way in which its brushes have been received and with the outlook for increased business in the near future.

Roth Bros. & Company, 28 and 30 Market Street, Chicago, report a large increase of business for the past month. Among other orders recently filled was a small lighting installation for Rangoon, India, consisting of one twenty-light dynamo, engine and fixtures.

Dynamo Brushes and Porcelain Fittings. The Electric Appliance Company, Chicago, is distributing two very neat and tasty circulars of some of its specialties and staple goods, one circular being devoted to porcelain tubes and insulators, and the other to sparkless and Boudreaux dynamo brushes.

Knife Switches. The Western Electric Company, Chicago, has issued a new price list of its high grade Type "E" and "Q" switches. The sizes in the several forms in which the switch is made aggregate not far from a hundred, each of which in the list has a distinguishing number and a telegraphic code word.

Fred. M. Locke, Victor, N. Y., has reason to feel elated with the success of his patent triple petticoat china insulators and steel pins. These insulators have been in use for two months, without showing the least sign of leakage, on the power transmission line between Newcastle and Sacramento, Cal., carrying 1000 HP at 15,000 volts a distance of 30 miles.

S. C. Strock, 50 Broadway, New York, has recently received, it is reported, the largest order ever placed for manufactured tapering yellow pine poles. The order was from the American Telephone & Telegraph Company, and was for 8000, ranging in various lengths from 25 ft. to 55 ft. Mr. Strock was formerly connected with the General Electric Company.

The Strowger Automatic Telephone Exchange, 947 The Rookery, Chicago, reports that it is just finishing an installation of its automatic telephones at Augusta, Ga., and Geneva, N. Y., and has also just taken a contract for an installation at Denver, Colo. This company is running days, nights and Sundays and is employing at present a force of about 100 men.

Mr. Chas. D. Shain, 136 Liberty Street, New York, announces that he has accepted the selling agency for New York State, of the Stevens flush switch, made by the Electric Protection Company. The mechanism of this switch is enclosed in a porcelain case, and nothing is in sight but an ornamental face plate set flush with the wall, and push buttons inlaid with mother-of-pearl.

The Bryant Electric Company, of Bridgeport, Conn., is constantly getting out handsome new catalogues and circulars to illustrate its new specialties. The company is now just out with its latest catalogue called No. 10, which everyone interested in switches, sockets and other specialties of like manufacture should send for. It is mailed free to anyone asking for it and mentioning the American Electrician.

The Keystone Electric Company, Erie, Pa., has recently been compelled to run until 10 P. M. with a full force of men, in order to keep up with orders. The company is preparing to bring out a full line of multipolar dynamos and motors, a number of sizes of which are now ready. In its elevator work the company is now especially busy with orders from all over the country.

Fuse Wires. A new illustrated price list and descriptive circular has recently been issued by the Chicago Fuse Wire & Manufacturing Company, 153 Lake Street, Chicago. This company has recently equipped its testing laboratory with some of the latest instruments, and intends to make its product in all respects of the highest grade. Mr. W. R. Goodman is the manager of the company.

Pole Insulators. That improvements in pole fittings are keeping pace with other advances in electrical construction is shown by a glance through the pages of a catalogue issued by Fred. M. Locke, Victor, N. Y. Among improved devices of various kinds illustrated are a new type of china pole, triple-petticoat insulator, several forms of indestructible

steel insulating pins, and a channel steel two-pin break-arm.

Charles Wirt, 1028 Filbert Street, Philadelphia, has received a flattering testimonial from the engineer of the Kinsley Restaurant, Chicago, as follows: "The Wirt dynamo brushes which you furnished for our Edison dynamo, four years ago, have been in use seven days a week and about fifteen hours per day ever since. The brushes are still good for some time to come, and the wear on the commutator is imperceptible."

The Consolidated Electric Company, 215 Lake Street, Chicago, has recently been reorganized. Mr. C. P. Emmons, for several years connected with the Emmons Electric Company, succeeds Mr. L. B. Scott as president, James N. Moore still occupying the position of secretary and treasurer. This company reports quite a number of very substantial orders for the month, and also states that its business is better than for some time past.

A. Louis Kuehnsted, of the Chas. E. Gregory Company, Chicago, has just returned from an Eastern trip loaded with bargains. Among the recent installations made by this company are a 750-light latest type Westinghouse alternator, five 30 and 20-light Sperry arc machines with 90 arc lamps, a large number of motors ranging from 5 to 50 HP, together with many incandescent dynamos and several Crocker-Wheeler motor generators.

The Puritan Electric Company, of 150 Nassau Street, New York, has had a phenomenal success with its noiseless long-life arc lamp for alternating circuits. Mr. Stewart W. Wise, president, is in charge of the New York office. In the New England office, 178 Devonshire Street, Boston, Mass., the company will be represented by Messrs. J. B. Chamberlain and Malcolm H. Baker, who are making a great hustle amongst the New England stations.

The Iron-Clad Rheostat Company, Westfield, N. J., has issued a new price list of theatre dimmers, which covers the ground thoroughly and in a great variety of styles. We learn that there are over 2500 iron-clad dimmers in daily use, ranging from 1 to 1440 lights capacity, a number of which are fitted with interlocking mechanism. Theatre dimmers are the specialty of this company, and its claim of leader in this line is well supported by the number and character of its patrons.

The Phœnix Interior Telephone Company, of New York, recently moved its offices and factory from 163-68 Greenwich Street, to 93 Washington Street. This company started in business about two years ago in a very small way, and its growth is certainly extraordinary, as its new quarters occupy the entire building, consisting of five floors and a basement. The plant is being fitted throughout with machinery, and as the building has its own power plant, the building will be lighted with electricity.

The Billings & Spencer Company, of Hartford, Conn., has brought suit in the United States Circuit Court, at Cleveland, O., against the Van Wagoner & Williams Hardware Company, of the latter city. The complainants allege that the Cleveland firm has infringed a patent owned by it on commutator bars or segments, which patent is held to be very valuable. The court has been asked to grant at first a temporary, and finally, a permanent, injunction, and to award an accounting and exemplary damages.

The Electric Appliance Company, of Chicago, has just completed the distribution of its calendar and moonlight schedule for 1897. The calendar is a very large and elaborate affair, and the feature of a complete and accurate moonlight schedule makes it useful as well as ornamental. The Electric Appliance Company has tried to distribute these calendars very generally to the Western trade, but if any have been overlooked, they will receive one on application to the Electric Appliance Company, 242 Madison Street, Chicago.

The Advance Electric Company, Indianapolis, Ind., is the recent successor of the late firm of McCurdy & Smith, and is situated at their old stand, 94 and 96 N. Meridian Street, Indianapolis, Ind. It is an incorporated stock company and its officers are D. D. Smith, president; Harry B. Marsh, secretary and engineer; Charles H. Talmage, treasurer. This company has just put in a select stock of new goods, and is prepared to do a wholesale, retail and construction business. Mr. Smith, of the late firm, has been retained in the management of the new.

A New Incandescent Lamp Firm. A new concern to enter the high grade incandescent lamp field is the Manhattan Incandescent Lamp Company, of St. Paul, Minn., which is already doing an extensive business, especially in the West. This company guarantees its lamps not to blacken and to show the best maintenance of candle power and life. The Manhattan lamp is sold under a guarantee and, it is claimed, at a price as low as a strictly high grade lamp can be sold. The concern has a capacity of 2000 daily, and is prepared to prepay freight and make shipments promptly to any part of the country.

Mr. T. C. Rafferty, who is probably one of the best-known men in the electrical supply business in the country, is now associated with the Metropolitan Electric Company, of Chicago, having disposed of all his other electrical interests. All of Mr. Rafferty's friends and customers will undoubtedly be pleased to learn of his new connection, which will afford him ample scope for his energetic work, enabling him to take care of his customers' wants in a befitting manner, and renew old and pleasant trade relations. The Metropolitan Electric Company is to be congratulated on its foresight in securing his services.

The Fairbanks-Morse Company, Chicago, has just completed the installation of one of its 15-HP gas engines, running a dynamo for lighting the company's store and warerooms. The dynamo is a 125-light machine, made by the Gibbs Electric Company and installed by Kohler Brothers. The engine is belted direct to the dynamo, and as the light produced shows no variation it may be said to be entirely successful for the purpose intended. This company makes a specialty of gas engines for electric lighting service, and has perfected its machine, with the object in view of producing an engine for isolated lighting.

Static Ground Detectors. The Stanley Electric Manufacturing Company, Pittsfield, Mass., writes to call attention to the fact that it has had a static ground detector on the market for two years and that its use is fully covered by a United States patent dated Feb. 11, 1896, granted to Mr. John F. Kelly. This explanation is called forth by a paper read at the recent meeting of the Northwestern Electrical Association, in which Mr. H. C. Wirt recommends the use of a static instrument as a means of detecting grounds, and states that the General Electric Company will have such an instrument on the market in six weeks.

Mr. W. McCullough, who has been looking after the Canadian General Electric Company's interests for the past three years in the West, is now representing Mr. Hugo Reisinger, 38 Beaver Street, New York, sole importer of the celebrated "Electra" highest grade Nuernberg carbons. While the Canadian General Electric Company regrets parting with one who has always been to the front where anything electrical was required, Mr. Reisinger is to be congratulated on his good fortune in securing the services of such an energetic salesman. His numerous friends will be pleased to learn of his new connection and will wish him much success in his new position.

The Ball Engine Company, Erie, Pa., reports the following sales made in the past 30 days: Direct-connected, one 400-HP, one 150-HP, one 125-HP, two 20-HP, one 60-HP, one 50-HP and two 35-HP engines; vertical cross-compound, one 400-HP, four 200-HP and one 100-HP engines; other types, two 175-HP, one 110-HP, one 100-HP, three 70-HP, two 60-HP, one 50-HP and five 25-HP. Of the above engines one—that of 400 HP—was shipped to Russia, and five to Mexico. Among recent orders is one from the Apollo Iron & Steel Company, Vandergrift, Pa., for 150-HP vertical compound engine, to be direct-connected to a 90-KW General Electric dynamo. This company has already an electric light and power plant operated by three 400-HP tandem compound Ball engines.

The Ideal Electric Corporation, Thirteenth and Hudson Streets, New York, is kept busy filling orders for La Roche alternators, both large and small, as well as for a new long-burning alternating arc lamp, which is claimed to be the best and only lamp requiring no attention, and which will burn 100 hours with one trimming without any further adjustment of the alternating current. These lamps are made to burn on 65 and 110 volts, no economy coils being used for them, nor special transformers. The lamp department of the above company is reported exceedingly busy, having all the orders it can take care of at the present time. The switch department of the same company also reports that business is very large in its all-coppered switches, of which it is making one of the finest lines in the country.

Messrs. F. B. Kinsman and A. A. Knudson, two electrical engineers, well and favorably known, have formed a partnership under the firm name of Kinsman & Knudson, as consulting and supervising electrical engineers, with offices at 66 Broadway, Manhattan Life Building. The excellent record of both of these gentlemen, as inventors of several useful improvements in the different branches of electrical science now in daily use, as well as their good standing as business men, entitles them to more than passing notice, and it is not difficult to predict a successful outcome from a union of this nature. We understand the firm proposes to give special attention to electrical questions in municipalities, their past experience well fitting them for this class of work.

Porcelain-Lined Outlet Boxes.—The H. Ward Leonard Electric Company, of Hoboken, N. J., has secured the exclusive right to the manufacture and sale of the various types of outlet boxes, switch boxes, junction boxes, floor boxes, cable boxes, drop cord boxes, receptacle boxes, etc., which have been known to the trade as the Mailloux, De Rycke, Krantz, Mountain and Soons boxes, and is supplying the trade with these boxes porcelain-lined instead of paint-lined, as heretofore, the prices being in all cases equally as low as heretofore and in many cases much lower. The porcelain lining makes a perfect insulation for the purpose, as it is unaffected by heat, cold, acids, alkalies, oils, or in fact any chemicals or conditions met with in practice. The insulation is guaranteed to measure over ten megohms and to resist 2000 volts alternating E. M. F.

Machado & Roller, 203 Broadway, New York, announce that they have become the sole agents for the United States for the celebrated A. E. G. incandescent lamps, and have made arrangements to carry a stock of 50,000 lamps in New York City, so that they will be able at all times to make prompt deliveries. While the lamp market is already crowded, there is always room for a first-class article, and relying upon this fact, Messrs. Machado & Roller will offer to the trade a lamp that represents the highest attainment possible in the present state of the art of lamp making. Competitive tests have proven that the A. E. G. lamps are in reality "all extra good" and have a remarkably long average life and a very high rate of efficiency throughout the entire period. They are, moreover, perfect in all mechanical details and of a fine appearance. They are furnished to the trade at standard prices.

The Chicago Armature Company, 14 North Canal Street, which has recently reorganized with U. L. Swingley, president and treasurer, W. Wright, manager, E. B. Bronson, secretary, reports just having completed several large orders from Washington and New Orleans, and that its shops have been working day and night for the past four weeks. Enquiries are coming in daily for the rewinding of armatures and for commutators, both new and for refilling. The company guarantees all work done by it and uses nothing but the very best material obtainable; all work is thoroughly baked before shipping, so that there is no trouble with armatures burning out through being green when put into operation. The company has just published a new catalogue and price list for electrical repairs, having listed all the well known makes of arc, incandescent and motor armature and field rewindings and commutator refillings, as well as duplicate armatures for any system.

A Prompt Delivery of Transformers. The Central Electric Company, Chicago, secured an order for transformers, aggregating 9000 lights capacity, on the evening of Jan. 13, delivering the same day from its Chicago stock 2000 lights capacity, and placing with the Wagner Electric Manufacturing Company, for which it is general Western agent, the balance of the order, of 7000 lights, via long distance telephone, communicating direct from its office with the Wagner Company. By ten o'clock on the morning of the following day the goods were loaded into a special car, reaching Chicago the following morning, and being installed complete at the Coliseum by Mr. D. Avery Kimbark, electrical engineer for the National Board of Trade of Cycle Manufacturers, on Jan. 16. From a point of promptness, this shipment is believed to be a "record breaker," not only with reference to the shipment, but also regarding the manner in which the installation was made by Mr. Kimbark after the goods were turned over to him.

The Conover-Goe Company is the name of a new electrical firm that has just opened offices at 1439

Monadnock Block, Chicago. While the firm is new in name, Mr. Geo. W. Conover and Mr. David E. Goe, the members composing it, have been known for many years in the electrical business. Both gentlemen were in the early days connected with the Electric Supply Company, which gave them an extended experience. Since that company went out of existence, Mr. Conover has been for the past three years the Western representative of the Perkins Electric Switch Manufacturing Company. Mr. Goe, since leaving the Electric Supply Company, has been, for the past two years, connected with the Central Electric Company as manager. The new company will handle a number of well-known specialties, including agencies for the Paragon Arc Lamp Company, the Gibbs Electric Manufacturing Company and C. S. Knowles, of Boston. In addition to these, the firm will also act as sole selling agent for the C. H. Dicke Tool Company, of Downer's Grove, Ill. With the wide experience and popularity of the men composing it, the new company starts out with every assurance of success, and the AMERICAN ELECTRICIAN extends its best wishes.

Underground Electric Railway Conduit Systems. In a letter to us Prof. F. B. Badt, secretary of the Siemens-Halske Company of America, refers to statements made from time to time by certain competitors that they absolutely own and control the patents covering all underground trolleys. This statement, he says, does not refer to the Siemens trolley or contact bar, the well-known device in use all over the world, which has been described repeatedly. This device makes a sliding contact with the trolley wire, making overhead construction very simple and doing away with the necessity of switches and frogs, besides making it impossible for the device to be "off the trolley." Professor Badt also refers to other statements made that certain American companies have patents on electric railway conduits and have installed "what they pleased to term the Budapest conduit system." It is a well-known fact, he adds, that the first successful electric conduit system—the Budapest conduit system—was installed by Messrs. Siemens & Halske, Berlin, and all United States patents covering the main features of this system are owned and controlled by the Siemens & Halske Electric Company of America. In conclusion Professor Badt states that the Siemens & Halske Electric Company is prepared to furnish complete trolley stands and trolley contacts and to install complete electric conduit railway systems under the patents it owns and controls, or it is willing to license prospective customers under these patents.

NORTHWESTERN ELECTRICAL CONVENTION NOTES.

The Chicago General Fixture Company, was represented at the recent Milwaukee convention of the Northwestern Electrical Association by L. W. Kittman.

The Chicago Insulated Wire Company, was represented by secretary and treasurer Wm. M. Smith.

Mr. J. C. Wormley, representing J. C. Wormley & Company, was ever on the alert for orders for lamps.

Chas. H. Rockwell, treasurer of the Buckeye Electric Company, represented his company at the convention.

Mr. Geo. S. Searing, Chicago representative of the Hart & Hegeman Company, looked after the interests of his company in a very able manner.

W. R. Brixey, of New York, spent a few hours at the convention. The many friends of Mr. Brixey only trust that his next visit to the Northwestern Electrical Convention may be of longer duration.

Mr. Geo. Cutter, of Chicago, is not only an electrician, but a politician. His happy speech at the banquet would entitle him to the nomenclature of "de peach," not of the Bowery, but of Chicago.

The Fort Wayne Electrical Corporation was represented by Mr. Wm. J. Buckley, who moved about among the delegates, putting in many good words for his company's products, and winning hosts of friends by his geniality and brightness.

The Eddy Electric Manufacturing Company had a hustling representative in the person of Mr. M. E. Baird. Mr. Baird has come to be recognized as a convention fixture, and his genial countenance would be at once missed, should he ever fail to attend.

The Chas. E. Gregory Company, was represented by its treasurer and general manager, Mr. A. Louis Kuehnsted. This company called special attention to its repair department, which, it claims, is one of the leading establishments of its kind in the West.

The Metropolitan Electric Company, of Chicago, was well represented in the person of Mr. W. C. McKinlock. It is needless to say that the new Metropolitan oil filter was well introduced. Mr. McKinlock also exhibited a new overhead joist-boring machine.

The Dearborn Drug & Chemical Company, of Chicago, made many friends through its agreeable representative, Mr. S. E. Christie, who demonstrated his wide practical knowledge of the business in the thorough and satisfactory manner in which he answered all inquiries.

Mr. Chas. E. Gregory, of the Elliptical Carbon Company, Chicago, also attended the convention. An electrical convention without Mr. Gregory would be like a song without a chorus. His success with elliptical carbons has already won him an envied reputation in the carbon field.

The Peckham Motor Truck & Wheel Company had no exhibit at the convention, but its interests were well looked after by Mr. W. H. Gray. Mr. Gray made many friends at the convention by his courteous, gentlemanly bearing toward all with whom he came in contact.

Mr. T. Selby Lane, secretary and treasurer of the Electrical Exchange, of Chicago, was one of the hustlers at the convention. Mr. Lane is one of the most aggressive, energetic workers among the electrical fraternity, and by his thoroughly business-like and gentlemanly efforts made a host of friends.

The Electric Appliance Company, of Chicago, was represented by its president, Mr. W. W. Low, and his able assistant Mr. Frank McMaster. They showed an excellent line of supplies, which, while not entirely electrical, were nevertheless of much interest. These two energetic men kept matters pertaining to their appliances to the front as usual.

The American Rheostat Company, of Milwaukee, was represented by President L. T. Gibbs and Vice-President Frank R. Bacon. Although this company is a comparatively new institution, yet judging from the already very satisfactory business which it has done, there is every indication of a bright future for its goods.

The People's Electric Company, of Madison, was represented by President L. W. Burch. There is, probably, not a representative of any electrical house better known in the Northwest than is Mr. Burch. The energetic manner in which he has pushed his company's business in his territory is well evidenced by the many good words and hearty good wishes which he received from the members of the convention.

The Graphite Rheostat Company, Chicago, had one of the most interesting exhibits at the convention. Mr. W. D. Mahaney, the representative, exhibited and explained a new type of Wheatstone bridge recently put on the market by M. A. Knapp. This instrument appealed very strongly to the central station men present on account of its convenience, accuracy and "quick finding" qualities. The low price of this instrument has made it very popular.

Donnelly & Bunce, a new firm, was represented by both of the gentlemen composing it. This firm represents the Sawyer-Man Electric Company, the Westinghouse Glass Factory, of Pittsburgh; the New York Insulated Wire Company, the Turner Brass Company, the Western Gear Company, etc. These gentlemen have many friends among the convention members, and judging from the amount of hustling they did, it is fair to assume that they gathered in many orders.

The Central Electric Company was represented by Chas. J. Burton and W. P. Upham. Mr. Burton's X-ray slides, made in the interests of his company, were shown on the screen immediately after Mr. Caryl D. Haskins' lecture, and attracted much attention. The two gentlemen representing this company are men of wide experience, and the manner in which they "got down to business" among the members of the convention was conclusive evidence that they had attended conventions before.

The Westinghouse Electric & Manufacturing Company, was represented by the following gentlemen: E. Dyer, W. S. Rugg and Henry Floy. Among its exhibits were comprised a 25-KW central station converter, some 4-KW central station converters and high-tension fuse blocks, a 100-volt, three-lamp economy coil, a 5-HP, two-phased Tesla motor; high-tension fuse blocks, and a 4-KW central station converter. A new type of junction box was exhibited by Mr. Jacob Cloos, the superintendent of the Pabst power plant. The current passed to two 25-KW indoor-type Westinghouse transformers, reducing the potential for the motor. A full line of catalogues and colored lithographs of the Westinghouse Company's new factory at East Pittsburgh were distributed among the visitors at the convention.

The General Electric Company was represented by Mr. B. E. Sunny, Western manager, and the following gentlemen: Mr. George K. Wheeler, Chicago; C. D. Haskins, Boston; H. C. Wirt, Schenectady, N. Y.; Percy A. Clisdell, Chicago; Thomas Ferris, Milwaukee. They exhibited a nice line of supplies in a parlor near the convention hall. A line of samples of the new Wirt alternating-current, short-gap lighting arresters, was displayed, together with their new 3-ampere and 5-ampere, long-burning arc lamps, type-H transformer and Thomson inclined-coil instruments, which were all favorably commented upon. A *Bulletin* of the University of Wisconsin containing a report of a complete test of modern American transformers, made by Mr. A. H. Ford, was distributed, together with other literature. The apparatus manufactured by the General Electric Company for generating X-rays, as shown by Mr. Haskins, was the hit of the convention and elicited universal favorable comment.

E. H. Abadie, sales manager of the Wagner Electric Manufacturing Company, of St. Louis, had one of the finest exhibits of the convention. Chief among them was a new alternating-current ceiling fan. This fan is operated at 100 volts and 7200 alternations, and is so designed that it can be operated at the same rate of speed as a direct-current ceiling fan. It has ball bearings which can be filled with oil to last under ordinary conditions of operation, say 18 hours per day, for a period of at least two years without replenishing. One of the chief points regarding this fan is the small amount of friction. The blades, being attached direct to the revolving field, can be set at any desired angle. Another exhibit of this company which attracted a good deal of attention was its 20-light standard-type transformer, with its latest X. L. fuse boxes. One of the handsomest souvenirs distributed at the convention—a handsome ink well in the shape of a transformer—was given out by the Wagner Company. Another exhibit was of its polished knife switches, among which was a quick-break baby switch.

B. & O. Notes.

In order to successfully handle the great crowds that are expected in Washington during the inauguration of Major McKinley, the B. & O. has arranged to lay about ten miles of additional side track to store sleeping cars and special trains on. The facilities this year will be very much greater than ever before.

General Passenger Agent Scull, of the B. & O. R. R., recently announced that he had secured the concession from the Joint Traffic Association, which makes it possible to give a stop-over in Washington on all first-class tickets sold over the B. & O. through that point. The fight over this concession was quite a bitter one and lasted for a long time, but Mr. Scull finally triumphed.

Engine No. 1313, which draws Royal Blue Line train No. 511 from New York to Washington, on January 24 made a run from Camden Station to Washington in thirty-seven minutes. The distance is forty-one miles. The train left Camden station at 4.02 and was in the Washington depot at 4.39. The run from Branchville to Trinidad, Washington's city limits, a distance of 8¼ miles, was made in five minutes.

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THE ELECTRICAL FEATURES OF THE INAUGURAL BALL.

BY LOUIS DENTON BLISS.

THE preparations for the inaugural ball at Washington, D. C., were more elaborate this year in every detail than ever before, the amount appropriated by the Inaugural Committee for this purpose being about $25,000. While the floral decorations and the bunting were of an exceptionally attractive character, the surpassing beauty of the electrical effects far outshone everything else.

The electrical features in previous years of this notable event, while frequently of an artistic and decorative character, never amounted to much from an illuminating standpoint, but this year the aggregation of no less than 150,000 CP in electric lights at an expense of over $5000, made the vast room in which the ball was held brilliant to a degree never heretofore dreamed of.

While designs of a varied character were submitted by many contracting concerns of New York and Washington, those submitted by Mr. John R. Galloway, of Washington, were considered by far the most artistic and practical of all. The conception of the plan for electrically decorating and illuminating the ball room was the joint work of Mr. J. R. Galloway and Prof. Chas. S. Pardoe, of the Bliss School of Electricity, both of Washington, D. C.

The ball room is located in the center of the Pension Bureau, where it is always held, and consists of an immense court bounded on all sides by officers of the Department. Around this court are several tiers of galleries faced with pillars, which form a satisfactory basis for decoration. The court is divided into three sections, all nearly of equal size, by two rows of massive columns over 100 ft. in height. The court is about 100 ft. wide × 300 ft. long and is entirely enclosed.

The electrical decoration involved the use of over 3000 incandescent lamps of 8 CP each, 50 arc lamps of 2000 nominal candle power each and over 4500 miniature lamps of 6 CP each. The current, for this purpose was supplied by the United States Electric Lighting Company, being conveyed a distance of 1¼ miles from its station, over three cables of 500,000 CM each, on the Edison three-wire system. The current was delivered at the Pension Office under a difference of potential of 220 volts between the outside mains, sufficient additional pressure being maintained at the station to keep the required voltage at the Pension Building.

One mile of No. 0000 stranded, flexible conductor, weather-proof insulation was required by the contractor for his interior mains. There were two sets of mains in all, one set completely surrounding the court on the ground floor and the other set in a similar manner placed upon the ceiling of the first gallery.

The mains were brought in as shown in Fig. 3, the ends being carried entirely around the building and connected to their beginning, thus constituting what is known as a "bridged-in" system, so that the current for the entire circuit fed two ways through the mains and the load thus equalized. These mains were supplied with current at a central point on one side. No other feeders were necessary. Upon the ground floor, and supporting the first gallery, are seventy-eight pillars, which were cov-

FIG. 1.—GENERAL VIEW OF BALL ROOM.

ered with white and yellow bunting. Upon the capital of each of these pillars was placed a cluster of eight lights, and depending from this on the face of the pillar were three circuits of three, three and two lights, respectively, making in all sixteen lights, which, when intertwined with green, produced a very beautiful effect.

Extending upward from the first gallery, the second series of seventy-eight pillars was treated in precisely the same manner, making in all 156 pillars, each illuminated with sixteen 8-CP frosted lamps. These sixteen lights were all connected in multiple, and were then tapped with a No. 12 wire directly into the mains, every alternate pillar being tapped on to the same side of the three-wire system.

The pillars on the first floor were all pended lights. This is shown clearly in Fig. 4. From the terminals of this arrangement, *A*, *B*, the No. 12 wire led directly to the No. 0000 mains.

As the work was all of a temporary character it was not necessary to solder joints, and the suspended lights were tapped directly on to No. 18 flexible cord. An ingenious arrangement designed for connecting the short length of flexible cord on the sockets to the main flexible cord, and keeping it from slipping down without soldering was designed and is shown at the left in Fig. 4, consisting of a specially constructed knot in the flexible conductor which proved very effectual.

These suspended lights were connected in sections at the laboratories of the Bliss School of Electricity by regular students, These lamps were also carefully wired up with rubber-covered conductor to withstand the action of the water.

As this fountain was located in the center of the room with no way of reaching it from below or above, it was necessary to remove a section of tiling from the floor, and cut a channel in the cement from the supply mains directly to the edge of the fountain. In this was placed rubber-insulated lead-covered conductor; the channel was then filled up with cement and the tiling replaced. The enormous flower pots on the central pillars were also supplied with current in a similar manner, so that the beauty of the effect was in no way marred by any visible electric light wires.

In the west end of the ball room on the face of the two galleries hung a United

FIG. 2.—VIEW OF BALL ROOM, SHOWING FOUNTAIN.

tapped into the first tier of mains, and those on the gallery into their respective mains. The lights on each pillar were protected by a single-pole bug cut out. The general appearance is shown in Fig. 2.

The construction of the clusters was accomplished in a simple and effective manner. Eight pieces of brass pipe of the proper length were bent to the required curvature, and then mounted in a block of wood in holes bored for the purpose, the sockets upon the terminals being connected up with annunciator wire, which was led out through the base, and there connected in multiple with each other. From this block, which was fastened in place around the capital of the pillar with strap iron, depended flexible cords, on which were connected the suspended lights...

where they were tested and then sent directly to the building to be hung.

In the middle of the ball room there was constructed a fountain of a novel character, which played continuously. In the center was a rocky mound where the water rose in spray, and here were placed a large number of 8-CP incandescent lamps interspersed among the rocks. These lamps were all set in water-proof sockets and connected up with rubber-covered water-proof wire, as a continuous stream from the fountain played over them all the time. Sprinkled profusely in the outer wall of the basin among rocks, bark and mosses arranged in a rustic manner, were 200 colored miniature incandescent lamps, which sparkled brilliantly amid the spray on the dark background.

States flag, 12 ft. long by 7½ ft. wide, with a back ground of the proper colors, on which were mounted 475 red white and blue miniature incandescent lamps. By means of a specially constructed commutator driven by a motor, the lights were thrown into circuit in sections, commencing at the left side and gradually progressing across the flag, thus producing the appearance of a flag waving in the breeze.

This apparatus was connected through a separate switch and cut-out directly upon the mains. Another emblem of an interesting character was an eagle surmounting a shield 6 ft. square, built up of 175 colored miniature lights.

Under the eagle which was mounted over the grand band stand were two flowing

streamers of green, each 25 ft. in length, in which were studded the names "McKinley and Hobart" in white frosted miniature lamps. These were connected up with annunciator wire in the same general way as the other set pieces.

On the stand occupied by the orchestra was constructed an immense arch after the

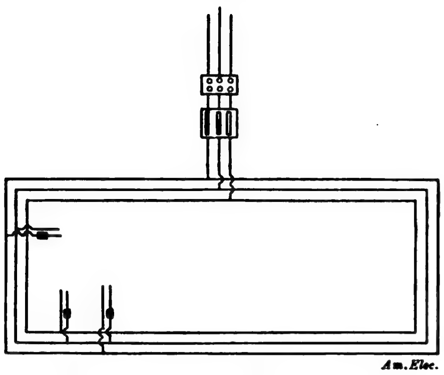


FIG. 3.—"BRIDGED IN" SYSTEM OF WIRING.

pattern of the entrance to the Transportation Building at the World's Fair. This arch was 70 ft. wide and 50 ft. high, and was called the "Golden Gate," and was one blaze of glory, being illuminated by 1000 miniature and 250 8-CP incandescent lights.

In the center of each of the three sections of the ball room, divided by the two rows of massive columns and suspended at a height of 115 ft. from the floor, were three immense

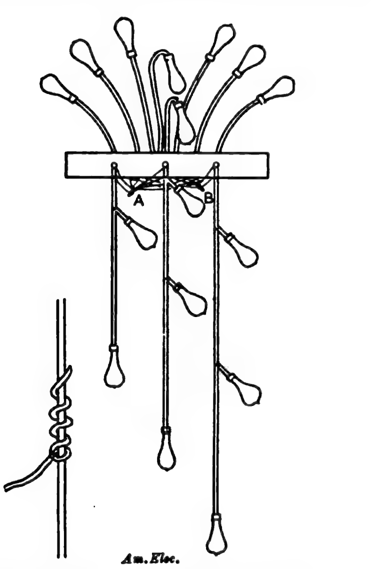


FIG. 4.—WIRING OF CLUSTERS.

domes, constructed of a framework of wood and covered with yellow and white bunting. These domes were 35 ft. in diameter at the bottom and 20 ft. in height, and around the lower rim of each were connected 200 clear white 8-CP incandescent lamps, giving the appearance at that height of a ring of fire.

Around the face of the second gallery were placed forty arc lamps in series, each provided with an opalescent shade to prevent objectionable glare.

These lights were supplied with current from a supply main direct from a Thomson-Houston machine at the United States Electric Lighting Company's station: Each lamp was swung by a guy wire on a wooden bracket about 3 ft. in front of the gallery, sufficient coil being left at each lamp to admit of its being drawn up into the gallery for trimming, as this operation had to be gone through three times. Ten additional arc lamps were placed upon the same circuit and swung in the various stairways that led from main floor to galleries.

The eight central pillars upon the main floor of the ball room had their bases decorated with a framework to represent immense flower pots, as shown in the illustrations. The drapery was white and gold, representing the wicker basket covering a flower pot, extended around each pillar to a height of 10 ft. from the floor, gradually spreading until at this point there was a shelf formed all the way round the pillar 3 ft. wide. On this shelf were placed magnificent palms, 25 ft. in height, banked in an artistic manner and all through these palms were sprinkled with the utmost profusion miniature colored incandescent lights, 300 being used in the decoration on each pillar. In addition to the arc lamps before specified, 25 "Helios," 150-hour, enclosed incandescent arcs were placed in the supper hall, and adjacent rooms upon the regular incandescent circuit.

All miniature lights in the whole decoration were connected eight in series on the 110-volt circuit, and were wired up with annunciator wire. The insulation was the same color as the material on which they were to be used. These were originally connected in rolls of one hundred sockets each in series and were cut into the required number for each circuit, as they were placed by the wiremen at the building.

All set pieces, such as the waving flag, eagle, golden gate, domes, etc., were provided with independent three-way vertical main cut-outs and three-pole switches, in order to cut them off completely and independently from the main circuit.

Signal bells were provided in abundance for communication between different parts of the building, the wires in every instance being concealed with bunting or other decoration. Metallic-circuit telephone communication was maintained between the various entrances and a box placed upon the roof of the building by means of which carriages were called when their owners desired. The driver's number was received by the man at the telephone and transmitted to the man on the roof, where it was immediately placed upon a lantern slide and projected by stereopticon on a large screen, "election-return style," from which point it could be read a long distance by the drivers.

The entire work was done under the supervision of Prof. Chas. S. Pardoe, E. E., and its successful completion and operation in every particular reflects great credit on his ability as a superintendent, upon the contractor, Mr. John R. Galloway, who so promptly and completely carried out his part of the work, and upon the wiremen who actually did the construction.

Wave Thought Transference.

In referring to Professor Crookes' latest "theory"—the transference of thought by brain waves—an English contemporary considers that its author obviously meant, not brain waves, but ether or electric waves originated by the motion of the atoms of which the brain substance is composed. A critic calls this "hypothesising an unknown agent obeying unknown laws of action."

THE APPLICATION OF ELECTRICITY TO BANK BURGLARY.

BY LIEUT. SAMUEL RODMAN, JR.

It seems proper at the outset to acquaint the electrical reader with a few of the developments which have taken place, both in the endeavor on the part of the manufacturer to produce impregnable safes and vaults and the no less progressive attempt on the part of the expert and the burglar to wreck these structures, either to prove their vulnerability or, on the part of the burglar, to secure, in addition, the valuables which they might contain.

From the old wooden receptacle studded with nails, various modifications of form and material have brought the steel and iron structures of the present day into use. Manufacturers have vied with each other in the endeavor to support their claims as to advantages one form or one material possessed. Invulnerability to mechanical means has been so widely claimed and at the same time so widely disproved, that the purchaser hesitated to accept anything as burglar-proof. Following close upon mechanical methods came the use of powder, and latterly nitro-glycerine and dynamite have been employed with such astonishingly successful results, both on the part of the expert and the burglar, upon at least one type of safe, that real security has to many seemed unattainable.

A few years ago the Government instituted an investigation into the various methods of safe and vault construction, and a great many tests were made on safes of various kinds in the endeavor to settle the question as to the superiority of any particular construction. The report of the commission making the investigation, together with full text and illustrations of experiments, was published early in 1894 as Senate Executive Document No. 20, 53d Congress, First Session.

There existed at the time, as is the case to-day, two distinct methods of construction. One was a receptacle made of plates of hardened steel bolted together, the other was a receptacle cast, as it were, in a solid piece with an extremely hard exterior. In matter of price the receptacle built of plates was, for a given capacity, much cheaper of the two. The results of the expert investigation proved that wedge, drill and explosive were too much for the plate safe, and practically ineffectual against the solid safe. However much these results may have disappointed the manufacturer, they have steadily advanced in substantiation both by the expert and the burglar, and though the effect has not been a sweeping condemnation of one system and the adoption of the other, it seemed to be merely a question of time when the facts supported by overwhelming testimony would bring about such a condition of affairs, and questions of price be thrown aside on the basis that worthless security is valueless.

Up to a short time ago, then, the solid cast construction bid fair to outdistance all competitors, and this might naturally be inferred from an inspection of the accompanying cuts, Fig. 1 being the work of experts and Fig. 3 representing the work of cracksmen. Fig. 1 represents a modern so-

called burglar-proof safe of plate construction, which its makers claimed would resist any attempt to open it for 24 hours. It was opened burglariously in 2 hours and 57 seconds in the spring of 1895. Fig. 2 represents a safe of general similar construction which was robbed by burglars early in 1894.

The seeming outcome in the matter of bank security has, however, been suddenly changed by the introduction of electricity as a factor in operation upon safes. Experiments have been carried on for the past few months, and it has been practically developed that a condition of affairs exists which renders all safes and vaults vulnerable. This is only a development in the use of the electric current whereby a wire is connected to a convenient source of electricity and the electric current brought up to the safe or vault to be operated upon. Take, for instance, a 110 or 220-volt system, and having figured upon the amount of energy required, connect a wire to one of the mains and lead to the safe, where contact is made by attaching it in any convenient way to the metal. Connect another wire to the other main, interpose a suitable resistance and attach to the other end a carbon stick of suitable length and diameter; place over the point of the safe to be attacked an oven in the form of a hollow box lined with fire clay or asbestos, and having a hole large enough to admit the carbon. Using a wooden or other insulating handle with which to manipulate it, approach the carbon to the safe and an arc of from 9000 to 10,000 degs. in temperature is created, whereby the metal of the safe is readily fused, and with a quickness which is astonishing a hole is made completely through the structure. The conditions to be met are a knowledge of the voltage and amperage delivered at the point where the connection with the mains is to be made and the interposition of that resistance which will reduce the voltage to about 60 and give an amperage of 150 or over. These conditions are not difficult to the electrician and with a little practice can be met by an intelligent person.

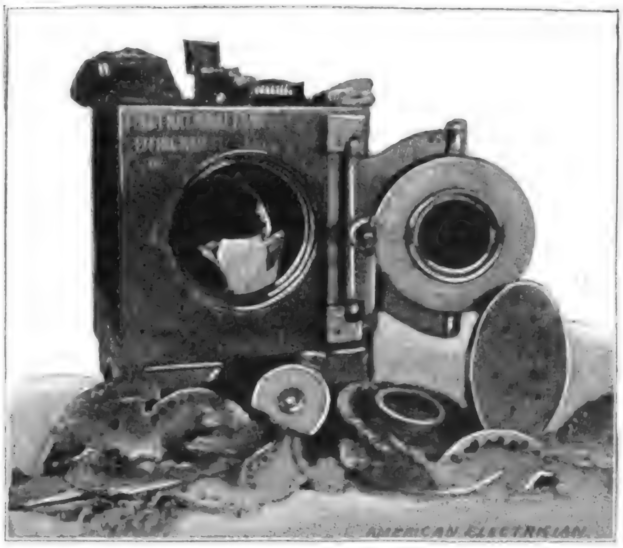


FIG. 1.—SAFE OPENED BY EXPERT IN TWO HOURS, FIFTY-SEVEN SECONDS.

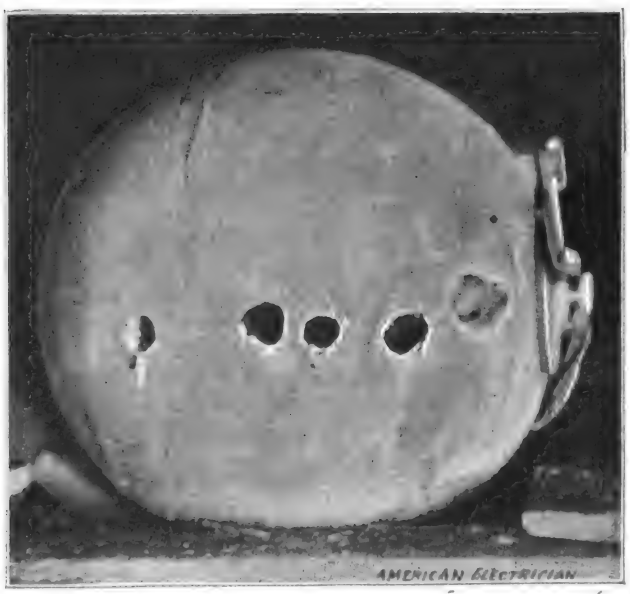


FIG. 2.—SAFE PIERCED BY ELECTRICAL MEANS.

FIG. 3.—SAFE OPENED BY BURGLARS.

Figs. 2 and 4 illustrate the work which has been done by this electric boring tool. Fig. 2 represents the solid cast construction and Fig. 4 the plate construction. The thickness of both of these safes is about 3½ ins. and the holes were made in from three to five minutes' time, connection having been made with a 220-volt Edison three-wire incandescent system. Flexible wires were used to convey the current to the safes and a resistance was introduced in the circuit so as to reduce the current to from 250 to 350 amperes and the voltage to from 50 to 80.

The practical electrician who will give thought to this matter will readily see that the burglar's electrical kit will be an extremely small and simple affair, and that which has to be carried to the point where the safe is to be attacked is easily portable. There need be no question as to the practicability, especially in our large cities, of obtaining all the electric current which can be desired.

In the experiments referred to the electric light main has been chosen, but the electrician can readily see that with proper manipulation the trolley system may also be made use of. Again, the storage battery is available and in this seems to lie the point of widest application, especially for the cracksman, for he can fill a room with these batteries near a bank and having arranged all detail make his attack when circumstances permit. The accompanying diagram (Fig. 5) outlines a simple representation of the electrical methods of attacking a safe. The oven perfoms the double duty of shielding the light of the arc from the eye and of confining the intense heat. The operation of the carbon is peculiarly interesting. This electric tool, as it may be called, seems automatically to bore and clean out the hole at the same time. The molten metal runs out with more fluidity the higher the heat, but should the metal tend at any time to partially cool and clog up before running out of the hole, as might be anticipated where the safe is very thick and the carbon has penetrated several inches, the arc will jump from the point of the carbon to that portion of it in the near vicinity of the clogging metal, fuze it out and them jump back again to the point and continue its boring. Some manipulation is, of course, necessary to render the operation successful, but no more than that which would be required to successfully use

a drill. A very important point for the burglar in considering this electrical operation is that it is practically noiseless. Explosives, while quick and certain in their action, are, unless manipulated with extreme skill, liable to defeat the enterprise by making too much noise.

It is easy to see then that electricity can be used by the cracksman, and it is perfectly fair to assume that he will not be slow in availing himself of the opportunities presented. He never has failed to take advantage of other means and methods, and the only thing is to anticipate this danger and put a practical obstacle in his way. The opportunity for effecting such an object is now presented as it never has been before, and Why? Because for the first time in history the expert has anticipated the burglar in fact. Hitherto the burglar, always on the alert to prosecute his nefarious business, has anticipated the safe manufacturer and has shamed the expert mechanic, and not until the burglar has demonstrated his skill has the mechrnic, as a general rule, endeavored to take steps to thwart him. There is only one man who has ever anticipated the burglar and succeeded in thwarting all means and methods which were then available. William Corliss, inventor of the safe which bears his name, proved by actual demonstration what other manufacturers have vainly endeavored to keep in the dark—that safes or vaults built of plates bolted together were not and could not be made

FIG. 4.—SAFE PIERCED BY ELECTRICAL MEANS.

burglar-proof against mechanical means and explosives. He abandoned the safe business some two years ago, but has left a structure which—leaving electricity out of the question—is as impregnable as the Rock of Gibraltar. But electricity has now become practically available to the cracksman, and because of the lower point of fusibility of cast iron, the solid cast structure becomes even more vulnerable than the steel and iron safes, though the point of vantage of the latter over the former is so small that for all practical purposes it may be disregarded.

The entire safe manufacturing fraternity must eventually accept the facts which are now developed, and he will be very foolish who endeavors to console himself with the idea that what he has not actually seen is not so. If he so desires he can see, and there are thousands of electricians capable of demonstrating the matter to his entire satisfaction, whatever may be the discomfiture that accompanies it.

The ultimatum of the matter as it now stands is simply this: All safes and vaults as

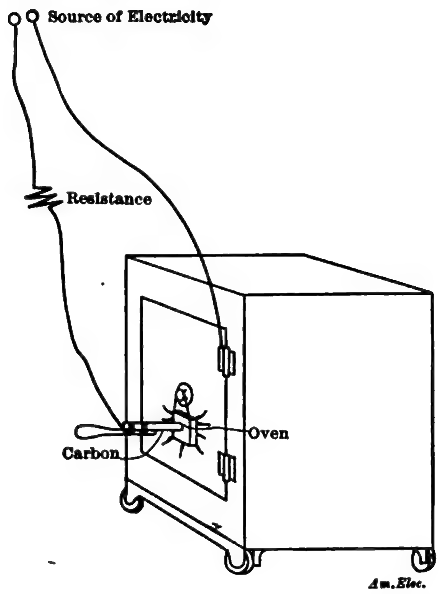


FIG 5.—DIAGRAM OF ELECTRICAL METHOD OF BURGLARIZING SAFES.

built to-day—no matter what the make—are reduced to the same level of insecurity; and all alike—manufacturer and banker—will learn, if he so desires, the truth of this statement. The problem of security must be taken up anew, and like any other problem presented, will be most successfully solved by those whose premises are correctly chosen and who are conversant with the existing condition of affairs and the points to be covered. Safes and vaults must still be used and they must be built with due regard to sudden attacks of a mob or a daylight hold-up. If too light they offer no security; if too ponderous the question of expense and other constructive questions render them impracticable. With these points guarded, however, the electric burning is not overcome, so that means must be devised to prevent the cracksman from getting at the safe or vault during the night or a holiday. There have been instituted as adjuncts to safe protection watchmen and burglar alarms. The electric current now renders the safe or vault itself only an adjunct.

Where then shall we find the prima facie barrier which shall be infallible and behind which the vast amount of funds and valuables now so absolutely unprotected shall be perfectly and unfailingly secure? Developments must surely come to meet the existing condition of affairs.

Tractive Magnetic Limit of Wrought Iron.

An English writer in some experiments obtained a tractive force for a cylinder of wrought iron of 381 lbs. per sq. in. of section, and concludes that the limit for wrought iron is within 400 lbs. per sq. in. of section.

ON THE CONSTRUCTION AND CALCULATION OF RHEOSTATS.

BY P. M. HELDT.

The resistance material of rheostats for the regulation of current or potential in electrical circuits may be metallic wire, carbon or graphite, or acidulated water. In the present article rheostats in which the first named material is employed will only be considered.

The different conductor materials used in the construction of commercial rheostats are iron, German silver and copper. Each of these materials has advantages in particular cases. The advantages of iron are cheapness and the ability to withstand high temperatures. German silver has a high resistivity or specific resistance and a low temperature coefficient. Copper is only used where large currents have to be carried, as, for instance, in electro-plating work, where one dynamo supplies several tanks requiring different voltages, and regulation is effected by inserting resistance into the circuits requiring the lower pressure. In this case copper, by virtue of its higher conductivity, makes it possible to use smaller conductors, thus facilitating the construction of the rheostat.

The following table gives the carrying capacity of tinned iron wire under different conditions. The last column gives the length of wire having a resistance of one ohm.

Size of Wire, B. & S.	Safe Current in Wood Frame.	Safe Current in Iron Frame	Safe Current for One Minute.	Feet per Ohm.
8	17.4	20.3	43.6	250
9	14.6	17.1	36.6	173
10	12.3	14.3	30.8	137
11	10.3	12.0	25.8	108
12	8.7	10.1	21.7	86.4
13	7.3	8.5	18.3	68.5
14	6.1	7.1	15.3	54.3
15	5.1	6.0	12.9	43.1
16	4.3	5.0	10.8	34.1
17	3.6	4.2	9.1	27.1
18	3.00	3.5	7.6	24.3
19	2.52	2.9	6.3	16.5
20	2 17	2.5	5.4	13.5
21	1.82	2.1	4.5	10 7
22	1.53	1.77	3.8	8.49
23	1.28	1.49	3.2	6.73
24	1.08	1.20	2.3	5.34

In designing motor-starting rheoststs, the values given under the heading "Safe current for one minute" should be used, while the carrying capacities given in the other two columns apply to dynamo field rheostats, motor regulators and such other rheostats as have to carry current continuously. No definite resistivity and carrying capacity can be assigned to German silver, as it is an alloy, and different makers use different proportions of the elements. In the tables given by Matthiesen the resistivity of German silver is given as 2.2 times that of iron. For the same rise of temperature a German silver wire would, therefore, carry about two-thirds the current of an iron wire of the same size. Most commercial German silver has, however, a specific resistance higher than that indicated by the above ratio.

The wires of rheostats are mounted in a number of different ways. They may be embedded in enamel or some other refractory insulating material; they may be wound on a plate of slate; they may be wound on a framework of iron rods insulated with

asbestos, or on insulated metallic spools with layers of asbestos between the layers of wire. Finally, the wire may be wound into coils which are stretched between insulators on an iron frame or in a frame of insulating material. When the wires are embedded in enamel, they are placed on the surface of and in close proximity to a cast iron base

FIG. 1.—DYNAMO FIELD RHEOSTAT.

plate which assists in radiating the heat. Slate is also quite a good conductor of heat, and plates of slate are often used for smaller rheostats. Spool-wound coils of wire sometimes present an advantage where the rheostat is only used for a short period at a time, as, for instance, in motor-starting rheostats, as this method of winding permits of getting a large amount of wire into a small space, and the capacity of the rheostat under such conditions depends more on its capacity for taking up heat than on the radiation. When spiral coils are employed, they are generally placed in a case with openings to facilitate the circulation of air.

The diameter to which spiral coils of wire are wound varies with the size of the wire. If for a given size of wire the diameter is taken too large, the coils must be stretched considerably to obtain the necessary stiffness. No. 24 (B. & S.) iron wire may be wound into coils of ½ in. diameter, while

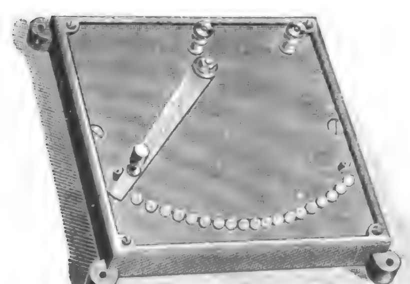


FIG. 2.—DYNAMO FIELD RHEOSTAT.

No. 16 may be wound into coils of from ¾ in. to ⅞ in. diameter, and other sizes proportionally. The wires are wound close on a mandril in a lathe and are stretched as they are put in position. For the larger sizes of wire a stretching of 20 per cent. is sufficient, while coils of No. 24 of 6 ins. or more in length must be stretched to about double their length. Some manufacturers place asbestos tubes inside coils of smaller wire, which, as they stiffen the coils, permit coils of larger diameter and reduce the stretching required.

Dynamo Field Rheostats.—Shunt and compound-wound generators are generally regulated by means of a rheostat in the shunt field circuit. In Figs. 1 and 2 are shown two dynamo field rheostats, both of which are of fire-proof construction. The form shown in Fig. 2 is intended for small machines, while that at Fig. 1 is adaptable to any size.

In the factory it is generally easy to experimentally determine the resistance required to cut down the voltage of a machine to the desired lower limit. Cases may, however, arise, where this is not handy, and the resistance can then be calculated, provided the excitation-voltage curve of the dynamo and the resistance of its field are known. The calculation may be illustrated by a practical example. The main curve in Fig. 3 is the excitation-voltage curve of a 1.5-KW 55-volt generator.

The machine is run at such a speed that without any load and without any extra resistance in the field circuit, it generates 65 volts. A rheostat is required which will cut down the voltage to 40. The field resistance is 36.4 ohms.

From the curve we see that at 65 volts the exciting ampere-turns are 6200, while at 40 volts they are only 2300. The ampere-turns are proportional to the voltage applied to

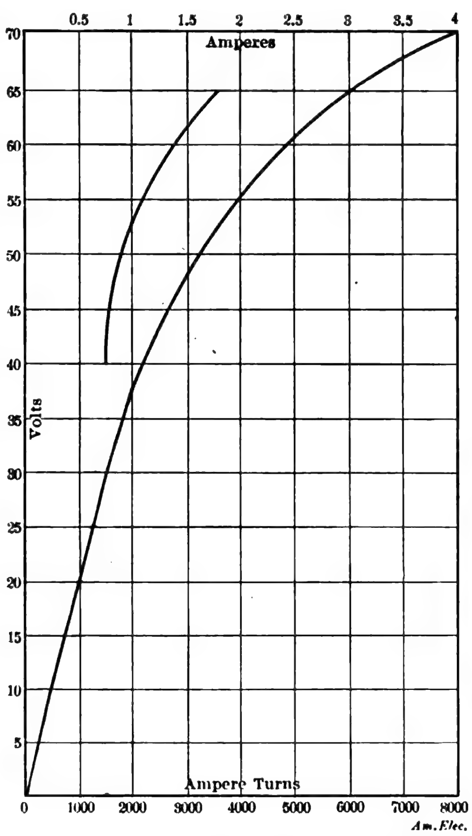


FIG. 3.—EXCITATION CURVE OF 1.5 KW, 55-VOLT DYNAMO.

the shunt. When 65 volts are being generated, the voltage at the terminals of the shunt is 65. At 40 volts it must, therefore, be $65 \times \frac{23}{62} = 24.15$. The rest of the E. M. F. $(40 - 24.15 = 15.85$ volts) must be compensated for by the drop in the rheostat. As the same current goes through field coil and rheostat, their resistance must be to each other as the drop of potential in them. Thus we get for the resistance of the rheostat $36.4 \times \frac{15.85}{24.15} = 24$ ohms. The largest current that any part of the rheostat ever has to carry is a little less than $\frac{65}{36.4} = 1.78$ amperes, and the smallest current $\frac{40}{36.4 + 24} =$ .65 amperes. After finding a few intermediate points in the same manner as we found the smallest current, we can draw a curve showing the field current for the different voltages. This curve is also shown in Fig. 3. For small rheostats, like the one under consideration, but one size of wire is generally used. In the present case an iron wire No. 22, or a German silver wire No. 20 would have the required current-carrying capacity. The total length of wire required would be for iron 204 ft., for German silver of the resistivity given above, 148 ft. In all large rheostats, however, the size of wire decreases from the "out" terminal to the "in" terminal. The calculation of the different portions may be illustrated by the present example. Supposing that twenty five steps of about 1 volt each are desired. From the field-current curve and the table of iron wire we see that the largest wire that would be used is No. 22. Of this we must make the first three sections of the rheostat. When the fourth section is inserted the field current is reduced so much that No. 23 will carry it. The resistance of these three sections is to be calculated in the same manner as the total resistance of the rheostat was calculated above. We then calculate the sections requiring No. 23, No. 24, etc., successively.

In some lines of work it is desirable to be able to change the E. M. F. of a generator very gradually; that is, by very small steps. This requires a large number of contact points, and as a rheostat with a large num-

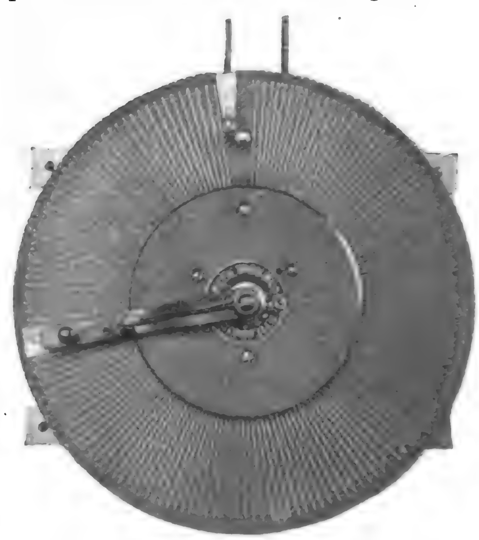


FIG. 4.—MULTIPLE-CONTACT RHEOSTAT.

ber of contacts as generally made (Figs. 1 and 2) is quite expensive to manufacture, several types have lately been brought out in which an attempt is made to simplify the construction. One of these is illustrated in Fig. 4. It consists of a plate of slate in the form of a concentric ring, the inside and outside edges of which are grooved to receive the resistance wire. The wire is wound on the plate in a continuous winding nearly all around the ring, as seen in the illustration. The plate carrying the wire is clamped between two other plates of slate. The front plate carries the contact lever, while to the back plate are fastened two strips of brass by

means of which the rheostat is fastened to the switch-board. The sliding contact piece bears directly on the wire. The rheostat illustrated has 180 steps.

Fig. 5 shows diagrammatically a rheostat in which the number of steps is equal to twice the number of contacts less one. It consists of an ordinary rheostat with a slightly different contact arrangement. The contact lever carries, in addition to the regular contact piece, another double contact piece which is, however, insulated from it. The main contact piece is wider than the distance between two neighboring contact points, while the two prongs of the double contact piece are narrower than this distance. Suppose that the current enters through the contact lever. It will then pass from contact 2 to contact 3 through the sections, a_1 a and b_1 b in parallel, and from 3 through the rest of the sections in series. The resistance of two sections in parallel is, of course, equal to one-half the resistance of a single section. When the lever is turned to the right, the main contact piece comes in contact with 3 and the prongs of the extra contact piece are between contacts 1 and 2, and 2 and 3 respectively. The parallel resistance is then cut out. This type was suggested by Vedovelli.

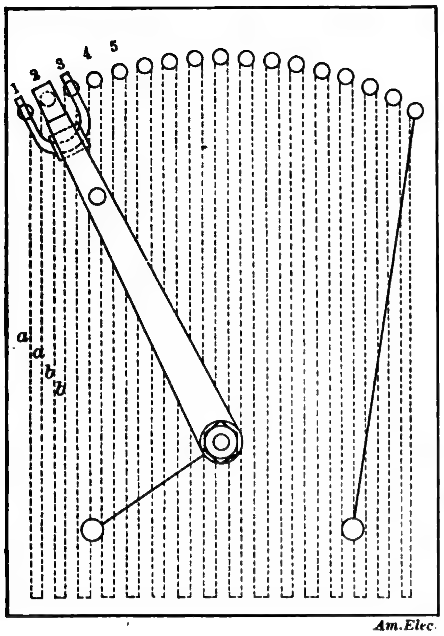


FIG. 5.—MULTIPLE-CONTACT RHEOSTAT.

Motor-Starting Rheostats.—When a shunt motor is started up, a resistance must be placed in its armature circuit, to prevent an abnormal rush of current. This resistance is cut out stepwise as the motor gains speed. Motor starters have generally but one size of wire all through, of sufficient cross section to carry the full load current for one minute. (See table above.) The resistance of the rheostat should be such that when it is connected across the mains, a current equal to the full load current of the motor will pass. From this condition the resistances of starting rheostats for motors of different outputs and voltages, compiled in the following table, have been calculated. (Ten per cent. is allowed for armature and friction loss in the motor.)

RESISTANCE IN OHMS OF MOTOR-STARTING RHEOSTATS.

HP	1	3	5	7	10	15	20	30	40	50
110V	15	5	3.	2.1	1.5	1	.75	.5	.37	.3
220	60	20	12	8.4	6	4	3	2	1.5	1.2
500	300	100	60	42	30	20	15	10	7.5	6

Motor-starting rheostats are nearly always automatic; that is, they have an electromagnetic attachment by means of which the armature is automatically cut out of circuit whenever the main current fails for any reason. This protects the motor from injury when the current in the mains is established again. Figs. 6 and 7 show two types of automatic starting rheostats. The rheostat in Fig. 6 has an electromagnet on its face plate. The coil of this magnet is in circuit with the field coil of the motor. The contact lever is of iron and has a spiral spring inside its hub. The magnet holds the lever in position when the resistance of the rheostat is cut out of circuit, but when the current in the field circuit ceases the lever is brought back to the dead button by the action of the spring.

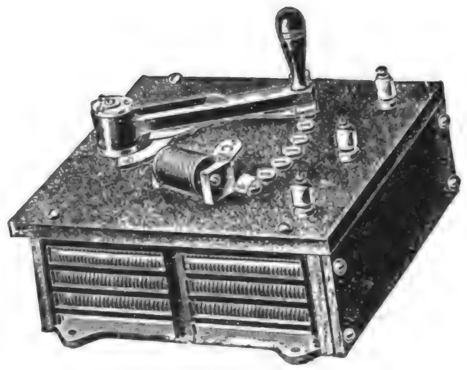


FIG. 6.—AUTOMATIC STARTING RHEOSTAT.

The rheostat of Fig. 7 has two levers turning on the same stud and connected by a spring, as seen in the illustration. One of these levers is the contact lever, while the other one serves as armature to an electromagnet and also as a switch arm. In the illustration, the contact lever is on the "off" button. In order to start the motor, the contact lever is slowly turned to the right. When the current fails, the contact lever remains in position, but the magnet lets go its armature and the circuit is opened at the switch on the magnet. When the motor is to be started again, the contact lever is first turned to the left. This closes the lower switch and the magnet takes hold of its armature. Then the contact lever is turned to the right, and the motor starts.

FIG. 7.—AUTOMATIC STARTING RHEOSTAT.

Motor-Regulating Rheostats.—The speed of motors may be regulated by means of a rheostat in the armature circuit. For the special case of a constant torque on the motor, the speed is proportional to the counter E. M. F. and the current remains constant, both for shunt and series motors. The resistance necessary to reduce the speed to a certain fraction of its original value may be found by the following rule:

Multiply the E. M. F. of the mains minus the drop in armature (and field in case of series motors), by the difference of unity and the given fraction, and divide the product by the current. The quotient obtained is equal to the required resistance in ohms.

Motor-regulating rheostats are now made, in which the contact lever is automatically held in any position and automatically released in case of overload or when the main current is interrupted. Fig. 8 shows a front view of such a rheostat. Two levers are rotatable on a stud fastened to the base plate. One of these, the contact lever, *A*, has an elbow-shaped side projection, *L*, with a number of notches on its outer edge, corresponding to the contact points. The other lever, *B B*, is of iron, and is two-armed. The lower arm serves as armature to the electromagnet, *M*. The other arm has pivoted to it at its extremity a third lever, *C*, provided with a catch, *c*.

The two arms of lever *C*, are of unequal moment and one of the arms rests continuously against a stud, *s*, fastened to the base plate. A helical spring (not seen in diagram) coiled around the hub of lever *A*, holds the lever against the stop, *S*, when the rheostat is not in use. When the lever, *A*, is turned to the right, lever *B* also turns on account of the friction between the two levers, and is thus brought near the poles of the magnet, *M*. The catch, *c*, engages into the notch corresponding to the contact point, on which the contact lever is left.

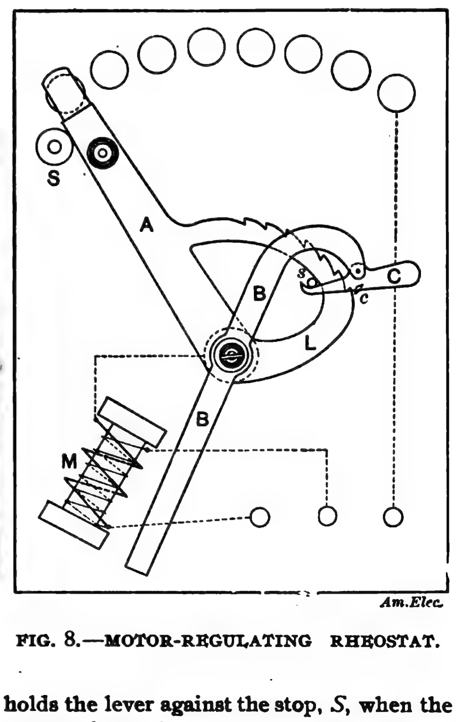


FIG. 8.—MOTOR-REGULATING RHEOSTAT.

The catch is locked by the electromagnet through the armature, *B*. The magnet, *M*, is wound differentially, one winding being in the field and one in the armature circuit of the motor. The turns of the windings are so proportioned that under ordinary conditions the effect of the field current predominates. When the current in the armature circuit rises above a certain value, the magnet is so much weakened that it cannot resist the action of the spring on the hub of lever *A*. It leaves go its armature, *B*, the catch, *c*, disengages, and lever *A*, returns to the "off" button. The same happens if the main or the field circuit should be opened. This construction is due to Mr. Charles Roth.

ALTERNATING CURRENT WORKING.

BY H. E. RAYMOND.

It is a settled fact, and generally now-a-days a well recognized one, that, in the design of all electrical systems from boiler or dam to the end of the line, it is policy and economy to engage the services of well-trained engineers and experts.

It is, however, to be deplored that the promoters of comparatively small systems too often trust to their own judgment, or that of their untrained employes, and generally obtain, as a result, a plant that in some details may be very ingenious and efficient, but, in its entirety, is generally decidedly inflexible, and poorly adapted to the service required.

It is probable that by degrees, this tendency will become entirely obsolete, but it is also probable that there will be a number of cases that will exist for some months to come, and it is in view of that fact that this article is written. Then also there are many men in charge of small stations who may be desirous of learning the practice of alternating-current transmissions, but who are so tied down to their surroundings that they have been unable to undergo any personal experiences in that line, or obtain any direct information from the experiences of others, and it is to be hoped that those who have been favored with any experiences will come to the front with what they know.

The kind of service and nature of loads, of course, must determine, to a great extent, the capacity and qualifications of all the apparatus, and, in particular, that of the prime movers. When the power transmitted is by means of polyphased alternating currents, employed in driving motors, either induction or synchronous, we find that the "the power behind the throne," be it engine or turbine, must be strong, simple, easily regulated, and quick to respond to great changes in load.

In starting alternating-current motors the power consumed is generally equal to, or a great deal in excess of, the full load running input, and is thrown on suddenly in addition. If the units are large, and the generator but slightly larger in capacity than the motor, the load on the generator when the motor is started is enormous, while as the motor rapidly runs up to speed, and, in the case of a synchronous motor, is synchronized, the load decreases very rapidly. If we are running by water power, it is easily seen that we must have gates easily and quickly operated, and a governor that will not only open and shut them to accommodate the load fluctuations, but will also make allowance for the inertia of the water, and not open or close them too much, as that causes see-sawing of the speed.

The character of the load also should determine to a very great degree the arrangement of wheels and dynamos. If there is to be but one wheel and one dynamo, the case narrows to limits that may be passed in silence. If there are to be two or more of each, the case is one that admits of considerable discussion. It seems advisable to go but slightly into the subject here, and only one or two methods will be mentioned.

Suppose the load is to be, say, on two generators, one carrying constant and even load up to its capacity, the other supplying a varying demand. With the first supplying lights or some source requiring an even potential, it would, in many instances, be allowable to drive from the turbines to a counter-shaft, and thence to the two dynamos. This is especially allowable if the generators are both loaded at their maximum capacity, and the loads differ in character and constancy. If one is to carry a railway load, the variations will be too great to allow of lights being run on the same circuit, and the voltage compounding necessary to this circuit would be unnecessary on the circuit supporting the constant load.

If lights are to be furnished, let them be connected to the generator under steady load and consequently constant voltage, and let the other circuit supply all varying demands of sudden or short duration.

If a good water wheel governor is employed, then all the necessary voltage regulation will be that required by slight speed changes.

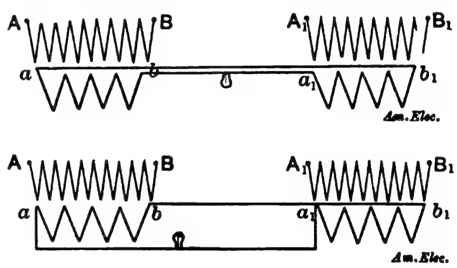
This is about as simple a way as any, but has this great disadvantage; the generators will not run well in parallel. It is almost impossible to make them run at exactly the same speed, and to keep the same relative speed under changes of load. If there is the slightest drag in one it will cause cross currents, in quantity proportional to the difference in speed, and no amount of field regulation will disperse them. Unlike direct-current machines, alternators in parallel must be in phase, and if one tends to run more slowly, it acts as a motor which the other constantly strives to bring into more "perfect" step.

If it is possible, the better and far more flexible arrangement is to have separate driving sources for each generator. Then, if it is desired to run them in parallel, the field strength for a certain voltage at certain loads on each may be determined, and these be separately regulated according to the load. Then even division of the load and avoidance of cross currents can be accurately adjusted by regulating their speeds.

For example, we found in one case, a water-power polyphased generating station, driving through four miles of wire, a synchronous motor carrying a small steady load, and a large fluctuating load, the latter being in street railway service.

Quite often the railway load would increase, at its maximum, much beyond the capacity of the motor, when a simple condensing engine was run in connection with the motor, being belted to the same shafting. The water wheel governor was set so as to regulate the system at normal speed, when the load was within the capacity of the motor, and the division of load between that and the engine was regulated by setting the weights on the engine governor at any desired point. In this way it was possible to either run the engine at its most economical point, or have it take as light a load as possible. The system was thus in part like one of parallel-running alternators, and the accuracy with which the load could be adjusted to each unit, has its parallel in the plan of separate wheels for each generator. Both the engine and the water wheel governor acted to regulate the speed, and, it may be of interest to note, the water wheel governor was most rapid in action and most sensitive to load fluctuations.

In order to determine whether or not alternators are in phase, it has been suggested by Mr. Steinmetz to connect two terminals directly together and place the primary of a transformer between the other two (or, in the case of three-phased machines, such two as may be determined by the method shown later). If this is done and a lamp connected into the secondary of the transformer, it will glow during opposition of phase, and darken when in conjunction or coincidence. The writer had occasion to try this method some years ago and while it was found satisfactory on open circuit, it was not satisfactory when the lines were in circuit, on account of the high tension caused when the coils were in phase-opposition.



FIGS. 1 AND 2.—PHASE INDICATORS.

With lightning arresters set to jump at an increase in voltage of 60 per cent. to 75 per cent. the increased voltage, even though of short duration, would cause a spark to cross the gap and the current at times to follow. In fact, in one instance the effect on the line of two armatures, of 500 volts each, in series caused a spark to jump a space of one-half an inch.

A safer method is to connect two of the terminals through a transformer primary, or choke coil, and the others in the same way as before. If lamps are placed in the secondary coils of both transformers the drop through the primaries will prevent the high voltage produced by the first method, while the lamps will glow and darken as before.

Probably a still better way is one that keeps the primaries entirely separate, until such time as they are to be thrown in multiple. Let *A* and *B*, and A_1 and B_1 be the leads to be paralleled. *A* is to be connected to A_1 and *B* to B_1. Across *A* and *B*, and A_1 and B_1, connect the primaries of transformers. If it is desired to have the lamp glow

brightly when the currents are in phase, connect b_1 to a and a_1 to b with lamp in series with either connection. If the lamp is to be dark when the currents are in phase, connect a to a_1 and b to b_1 through the lamp. It is easy to see how, in the first case (Fig. 1), the current in the secondaries, when a and a_1 are simultaneously $+$ or $-$, will flow from a to b, through the lamp and back through the windings, and in the second case (Fig. 2), how, to accomplish the same result the value of A and B_1 and A_1 and B must have $+$ or $-$ values simultaneously.

In phasing polyphased machines, it is necessary that the individual armature coils in the machines to be run in parallel, shall change values in the same rotation, lest that while one coil in each may synchronize, the others may be so wound or connected as not to do so. The simplest way to test this is to start a motor with one machine, let it stop, and then with the corresponding terminals of the second machine connected to the same ones to which those of the first were, see if it runs in the same direction. If this is the case, all that is necessary is a phase indicator across one coil on each machine, as in the cases spoken of before.

Of course, in using transformers in these methods it is necessary that the primaries and secondaries of both be wound in the same direction electrically speaking, so that if the primaries of both are in multiple on one line, the instantaneous positive and negative terminals shall coincide, or in any case be determined, and the connections governed accordingly.

PROTECTIVE DEVICES FOR TRANSFORMERS.

In a paper read before the recent meeting of the Northwestern Electrical Association, Mr. H. C. Wirt described several automatic devices designed for connection to the secondary wiring of transformers, so that in event of the high-tension primary current passing to the secondary wiring, it will be automatically connected to the earth, thus preventing any danger of a shock or the possibility of causing a fire.

The Cardew earthing device, shown in Fig. 1, consists of two metal plates, separated and insulated from each other by ¼-in. air space. The plates are held in a horizontal position. A thin strip of aluminum foil, about 3 ins. long and ¼ in. wide, is flexibly attached at one end to the upper plate, which is connected to the secondary wiring, and the other end is supported near to, but normally not in contact with the lower plate, which is connected to a good ground. If a difference of potential of about 300 volts exists between these two plates, the aluminum foil is attracted to the lower plate, and will remain in contact with it until the primary fuses are blown. This, therefore, automatically grounds the secondary whenever there is a difference of more than 300 volts potential between the secondary wires and earth.

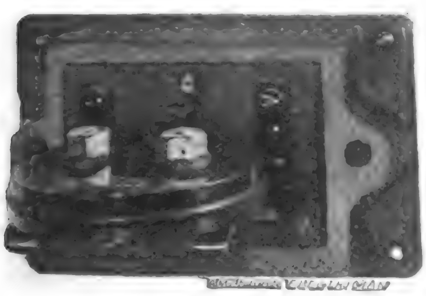


FIG. 1.—CARDEW EARTHING DEVICE.

Several thousands of these devices are in use in England, as such apparatus is required by a regulation of the English Board of Trade, specifying that in every case where a high-pressure supply is transformed for the purpose of supply to one or more consumers, some suitable automatic and quick-acting means must be provided to protect the consumers' wires from any accidental contact with, or leakage from, the high-pressure system, either within or without the transforming apparatus.

FIG. 2.—THOMSON FILM CUT-OUT.

On the three-wire system, the device is connected to the neutral wire. With small transformers it is connected to only one side of the secondary circuit, and with large transformers one is placed on each secondary wire.

Prof. Elihu Thomson has invented several protective devices. The "Film Cut-out," so called (Fig. 2), is quite similar in its action to the Cardew earthing device, the only difference between the two being that the plates are separated by a thin film of paper, which is pierced by a potential of 300 volts, making a good connection, and thus permitting the primary fuse to melt. The device was first commercially used in 1890. The transformers at that date were so poorly insulated that it was found that the primary current passed to the secondary wiring so frequently that their use had to be abandoned.

Prof. Thomson's transformer protective device, known as the "Ground Shield and Grounded Secondary," is shown in Fig. 3. The ground shield consists of a sheet metal covering, placed in the transformer between the primary and secondary windings in such a way that it is impossible for any current to pass from the primary to the secondary windings without connecting with the metal shield. The shield is connected to a good ground, and, therefore, the primary current will not pass to the secondary wiring.

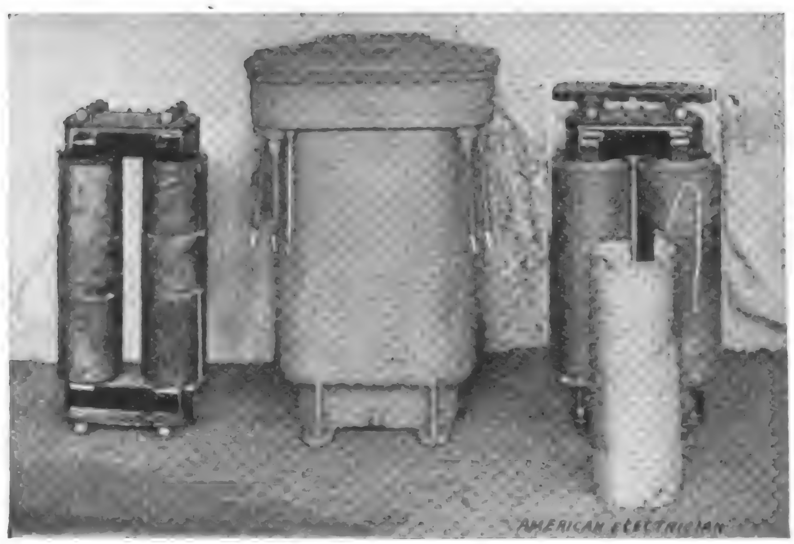


FIG. 3.—THOMSON GROUND SHIELD AND GROUNDED SECONDARY.

THE SELECTION OF INCANDESCENT LAMPS FOR USE IN TROLLEY CARS.

BY W. SONNEBERG.

The object of this article is to point out the necessity for discrimination in the selection of incandescent lamps for use in trolley cars. Let us assume a case which will be a fair criterion. A power house supplying current for trolley cars in city service, contains machinery capable of generating 550 volts, which it succeeds in doing at times. An average of the voltage at the station would not be higher than 525, with a possible minimum of 475 volts. In connection with this station we will suppose a line extending five miles in each direction therefrom—a fairly representative distance; and further suppose an ample feeder carrying capacity available.

Under such conditions as these, we may expect at certain times during the day, a fall of potential on the line of at least 50 volts with the full number of cars in service. Subtracting, therefore, the 50 volts loss on the line, from the station minimum of 475 volts, we have a probable minimum of 425 volts available at the ends of the line. This pressure divided among five lamps, provides but 85 volts for each lamp originally intended to be burned at 110. The result of

this diminution of pressure is clearly shown in the following table.

TEST OF A 16-CANDLE POWER 100-VOLT LAMP.*

Pressure.	Candle Power.
105	22.8
100	16.7
95	12.2
90	8.7
85	5.9
80	4.0
75	2.5
70	1.5
65	0.8
60	0.6

To those familiar with the operation of roads of this character it will be apparent that the case cited above is not exaggerated, but in fact rather a conservative one, when we consider the number of roads where the pressure falls as low as 300 volts.

We quote extracts from Preece's tests, as follows: "The continuous-lighting experiments show that the candle power falls off about thirty per cent. in 1000 hours, and the watts per candle power rise about twenty-eight per cent in the same time." Taking in conjunction with this, tests which have shown that a 16-CP, 110-volt lamp, worked at a pressure of 85 volts, when comparatively new absorbs about eight watts per candle power, it can readily be seen to what extent the inefficiency of lamps in street railway service may develop.

It is a well known fact that a very small increase in the current supplied to an incandescent lamp, is accompanied by a large increase in the light of the lamp. And it has been shown that the candle power varies very nearly as the sixth power of the current. That is to say, if a lamp gives one candle power when a current of one ampere is passed through it, then, if it were possible to force two amperes through, it would develop 64 CP.

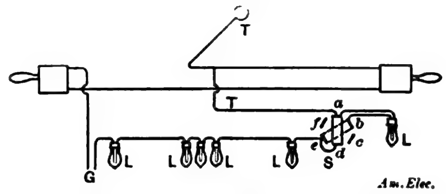
Before coming to any conclusion we will present, briefly, the other side of the question, which demonstrates the evil effect of increasing the pressure of a lamp above that for which it was intended. And perhaps we can do no better than to quote Prof. J. A. Fleming on the subject. In his lecture on "Electric Glow Lamps," he says: "Broadly speaking, however, the duration of an incandescent lamp is dependent upon the electric pressure at which it is worked, and if a lamp is marked to be used on a 100-volt circuit, then if it is used on a circuit at a pressure of 105 volts, its life would be greatly abbreviated, probably to one-quarter or one-fifth of the time which it would last if worked at normal pressure. On the other hand, if it is worked at a pressure of 95 volts, its duraion, accidents apart, will be greatly increased."

It is this phase of the subject which would seem to discourage any further argument that we might have to offer; yet, when one considers the short intervals of time, during which the lamp filament would be subjected to this excess of pressure, one might be tempted to sacrifice a few hours of the lamp's life if, by doing so, a much greater proportion of the energy expended would be efficiently utilized.

* Taken from Prof. J. A. Fleming's lecture on "Electric Glow Lamps."

While there is no infallible remedy for the evil, an improvement in the lighting service, may be made in either one of the following ways:

1. By the use of an auxiliary resistance in series with lamps of lower voltage than are ordinarily used; allowing this resistance to remain in circuit when the voltage is high, to protect the lamps from an excess of pressure, and shunting it when the voltage is low, in order to give the lamps the full benefit of the pressure available at such times. The range of this resistance would depend on the variations in voltage. During the early evening hours when the illumination should be the strongest, it is usually the weakest, as the maximum load comes on about that time. It is then that the resistance should be shunted. When the load again falls off and the pressure increases, bringing the lamps to fuller brilliancy, the resistance should be in circuit.



MOTOR-CAR LIGHTING CIRCUIT.

The moment at which to make this change in the circuit might be left to the judgment of the man in charge of the car (he having been first instructed in its use), or it might be predetermined from time to time by the electrician in charge.

2. By adopting the direct method of using lower voltage lamps without any auxiliary resistance, causing thereby a slight decrease in their useful life.

In the long run the additional cost of maintenance may be compensated for by the increase in the number of riders due to the better service furnished. There is no question of the boon it would be to those who insist upon reading on their homeward journey. If an auxiliary resistance is used, the most desirable form to adopt is an extra lamp. Let us see what results can be accomplished in this way. If we have a fluctuating voltage between the limits of 425 and 510 volts, it might be a good plan to use six 85-volt lamps in series, cutting out the extra lamp at low pressure and putting it in circuit when the voltage is high.

An arrangement for such a circuit is shown in the accompanying figure. *L* are lamps, *S* a 3-way switch, *T* the trolley, *G* the ground and *a*, *b*, *c*, *d*, *e*, *f* are clips of the switch.

Since writing the above we have subjected some incandescent lamps to an excess of pressure in order to test their life under such a condition. A number of 110-volt lamps were taken at random from a barrel lot and placed on a circuit that supplied each with a varying pressure, the average of which was 126 volts. The first lamp gave out in 150 hours and the second at the end of the 200th hour, after which the test was discontinued.

An American Honored.

Prof. D. E. Hughes has received the Albert medal of the English Society of Arts, the Prince of Wales making the presentation.

BOILER FEED PUMPS.

BY C. A. COLLETT, V. P., N. A. S. E.

The single-acting plunger pump is one of the oldest and best devices for feeding a steam boiler. If the stuffing-box is kept well packed with common hemp packing, this pump will plod along day after day, ever ready for action, and always diligent and reliable. It has but two valves, and they are both easily accessible and durable. It is a pump that never gives any trouble whatever, and costs little or nothing for repairs. But, unfortunately, this pump is a water forcer only, and besides this, it cannot be operated when the engine is stopped, since it is driven either by a belt or by gearing, and hence, it has been very generally superseded by the direct-acting steam pump.

There is scarcely a piece of machinery in a mill or factory that is subject to so much abuse, and charged with so much unnecessary expense for maintenance and repairs, as the steam pump, and this is owing in a great measure to the fact that the average engineer does not thoroughly understand its construction and functions. When the average engineer succeeds in firmly grasping the fact that a steam pump has nothing whatever to do with forcing water through the suction pipe into the water cylinder, then he will be in a better position to properly care for and run a steam pump.

To illustrate this point, we will select from a manufacturer's catalogue a single direct-acting steam pump with a water cylinder 6 ins. in diameter and 12 ins. stroke, and located at the mouth of a cistern open to the atmosphere. We will assume that the vertical distance from the surface of the water in the cistern to the top of the water cylinder is nearly 34 ft. We have chosen this distance because the atmosphere at the level of the sea will support a column of water, at about 62 degs. F., having a cross-section area of 1 sq. in. and a height of 34 ft. nearly. We will assume, furthermore, that the pump and its appendages and connections are perfectly air-tight, and that there is a gate valve attached to the lower end of the suction pipe, say, 1 ft. below the surface of the water, and which can be thrown wide open in an instant.

The water cylinder and suction pipe are both full of air and the gate valve is closed tightly. We start the pump, and after two or three strokes, or a sufficient number of strokes to exhaust all the air in the pump itself and in the suction pipe, we stop it. So far our pump has not handled a single drop of water, having acted only as an air pump. We are now satisfied that there is a perfect vacuum both in the water cylinder and the suction pipe. We now throw open the gate valve instantaneonsly; and the water in the cistern 34 ft. below the pump barrel, rushes up through the suction pipe and into the pump barrel, filling the same and the suction pipe clear down to the gate valve, and we have a column of water nearly 34 ft. high, supported by—what? Not the pump, surely, because that is standing still, not by suction because there is no such thing as suction, not by a vacuum, because there is no vacuum, the water having filled it or destroyed it. What then? Why, it is supported by the atmosphere whose pressure is

14.7 lbs. upon every square inch of water in the suction pipe, whether the pipe contains the fraction of a square inch in its diameter, or whether it contains a hundred, a thousand, or a million square inches. Let us see. A column of water 1 sq. in. in area and nearly 2.3 ft. high weighs 1 lb., and $14.7 \times 2.3 = 33.81$ ft, or 34 ft. nearly.

We would remind the reader that we have taken for our illustration an ideal pump, a perfect vacuum pump, and that such pump is never met with in practice, because air is an insidious element, ever on the alert to destroy a vacuum, and because it is impracticable to make the water end of a steam pump air-tight, and if it were so made, air would find its way into the water cylinder, through the suction pipe, since water itself contains air.

Another important point that the average engineer loses sight of is this: We can regulate the steam pressure to force the water out of the pump barrel at any velocity within the bounds of reason, but we have only the pressure of the atmosphere to force it into the water cylinder; consequently, we must regulate the velocity to suit the pressure. The theoretical velocity of water rushing upward through the suction pipe is found by taking the square root of the acceleration due to gravity multiplied into the head in feet. The head due to a pressure of 14.7 lbs. per square inch is 6.4 ft. nearly—thus $14.7 \times .433 = 6.365$, and $\sqrt{2 \times 32.2 \times 6.4} = 20.3$ ft. per second, or 1218 ft. per minute. But this velocity is reduced by the effect of entrance head, by the weight of the water in the suction pipe, and by the resistance of friction in the suction pipe.

To illustrate, we will take our catalogue pump 6 ins. in diameter water cylinder, and 12 ins. stroke. The area of the water piston is 28.27 sq. ins., and $28.27 \times 12 = 339.29$ cu. ins. the capacity of the water cylinder, and $339.29 \div 231 = 1.4688$ gals. of water per stroke of piston. Again $339.29 \div 12 = 28.27$ ft. per stroke, or a column of water 1 in. square and 28 + ft. long.

If the pump is run at 100 ft. piston speed per minute, and the suction pipe is 1 sq. in. area and 25 ft. long, the pump would not work, because the velocity of the water flowing through the suction pipe is 2827.44 ft. per minute, equivalent to 146.88 gals. of water per minute, and the friction loss in pounds pressure per square inch would more than equal the pressure of the atmosphere, admitting that a perfect vacuum obtained in both water cylinder and suction pipe. We need not go into figures to show that a suction pipe of 1 sq. in. area is too small for a 6 in. $\times$ 12 in. water cylinder; we merely make use of a few figures to show why it is so.

Authorities tell us that the velocity of the water in the suction pipe should not exceed 250 ft. per minute. Looking again in our pump catalogue, we find that the manufacturer has given this pump a suction pipe 4 ins. in diameter. Figuring again, we have $4 \times 4 \times .7854 = 12.5664$ sq. ins. as the area of suction pipe, and $2827.44 \div 12.5664 = 225$ ft. per minute velocity of water flowing through the suction pipe. Now, the friction loss consequent upon 146.88 gals. of water flowing through 100 ft. of 4 in. pipe, according to Ellis's tables, is about .69 lbs. per sq. in., but our suction pipe is but 25 ft. long, consequently we take one-fourth of this, or, .1725 lbs. per square inch as our friction loss. We may lower our pump and shorten our suction pipe, or we may increase the diameter of our suction pipe and reduce this friction loss to practically nothing.

We see now that there is no such thing as suction, and that a vacuum does not draw the water into the water cylinder. We will suppose that the vacuum in our pump is impaired to the extent of 4.7 lbs. per square inch, we would then have but 10 lbs. of atmospheric pressure per square inch, to force the water up through the suction pipe; thus $14.7 - 4.7 = 10$. Now, by proportion we have $14.7 : 10 :: 34 : 23.13$. Consequently we would be compelled to lower our pump nearly 2 ft. in order that the atmosphere could force water into the water cylinder.

Let us take a pump running at a piston speed of 150 ft. per minute, with a suction pipe 20 ft. long vertically, and if the net atmospheric pressure is just sufficient to keep the water cylinder amply supplied, we may increase the steam pressure and run the pump up to 175 ft. per minute, and thereby increase the quantity of water delivered per minute, providing the supply does not break. But the supply would in all probability break, because of the increased resistance of friction in the suction pipe consequent upon the increased velocity of the water without any increase of the pressure of the atmosphere.

Of course, if we could increase the pressure of the atmosphere at the same time that we increased the speed of the pump all would be well, but we cannot do this since the pressure of the atmosphere is a constant and unchanging quantity at the level of the sea.

It is believed by many that a steam pump, such as we are considering, will not handle hot water unless the water flows to the pump by gravity. There are steam pumps on the market that handle hot water having a temperature of 200 degs. F. successfully, with suction pipes as much as 18 ft. long vertically. Let us see how this can be done with a piston pump and very little piston clearance. We will suppose a hot well open to the atmosphere and holding water at, say, 153 degs. F. The total pressure per square inch due to this temperature, and measured from a vacuum, is 4 lbs. The weight of a cubic foot of water at 153 degs. F. is about 61 lbs. Then $14.7 - 4 = 10.7$. and $\frac{61}{144} = .4236$. Then $\frac{10.7}{.4236} = 25.2$, and $25.2 \times .8 = 20.16$, or say, 20 ft. for the vertical lift of the water.

It is well to always place a vacuum chamber on the suction pipe close to the pump, and when the suction pipe is very long, or has numerous fittings and valves in it, a vacuum chamber becomes indispensable. When the suction pipe is very long a foot-valve is also necessary. The vacuum chamber being constantly filled with water, when by reason of speeding up the pump, the water piston runs away from the inflowing water through the suction pipe, causing a break, a portion of the water in the vacuum chamber at once falls down into the suction pipe, filling the gap and restoring the continuity of the body of water flowing to the pump.

In time air will collect in the vacuum chamber to such an extent as to resist the entrance of any considerable quantity of water, and it must be expelled either by drawing it off through the pump, or by a small air-pump attached to the top of the vacuum chamber.

EFFICIENCY TEST OF A SHUNT DYNAMO WITHOUT A DYNAMOMETER.

BY THOS. G. CONNER.

The efficiency of a dynamo is the ratio between the power delivered and the power supplied, the difference between these two quantities being the power lost. The power delivered by the dynamo may be measured by means of a voltmeter and ammeter, and if we can ascertain the power lost, we can evidently calculate the efficiency.

The losses of a dynamo may be divided into three classes: 1°. $C^2 R$ losses; 2°. Friction; 3°. Hysteresis and eddy current losses.

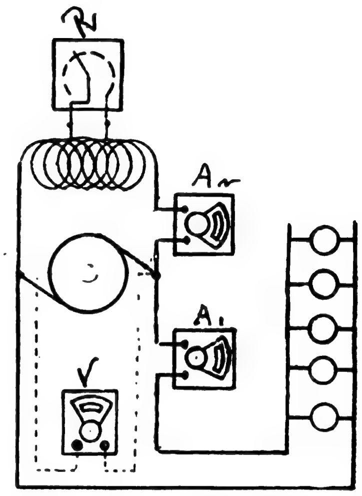


FIG. 1.—CONNECTIONS WITH LOAD.

The $C^2 R$ losses can be easily calculated by measuring the voltage, current in armature and in field, and resistance of armature. So long as speed, voltage and field current do not change, the losses in classes (2) and (3) are constant, whether the machine runs as a dynamo or as a motor.

To determine these losses, the following measurements are necessary: First, connect the dynamo as shown in Fig. 1, and run at the load to be tested. Adjust the field rheostat to give the proper voltage, and note the speed, measure the current in the fields and in the external circuit, calling these currents C_1 and C_2, respectively. Then connect the dynamo as shown in Fig. 2, and

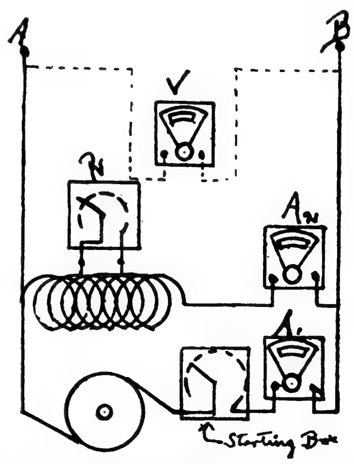


FIG. 2.—CONNECTIONS AT NO LOAD.

run as a motor at no load, A and B being supposed to be the terminals of another dynamo working at the same voltage as the dynamo under test. Adjust the field rheostat so that the speed will be the same as in the first experiment. Then losses (2) and (3) will be practically the same as when a dynamo.

Measure the current in the armature (C_m). The energy lost in the armature is $E\ C_m$, and since the $C^2 R$ loss at no load in the armature is so small as to be neglected, we can assume thst this loss, $E\ C_m$, is due entirely to friction, hysteresis and eddy currents.

The calculations then are as follows, R_a being the armature resistance :

(1) $C^2 R$ losses $= C_s E + (C_e + C_s)^2 R_a$.

(2) and (3) losses $= C_m E$.

Therefore, efficiency $=$

$$\frac{C_e E}{C_s E + C_m E + (C_e + C_s)^2 R_a + C_e E}.$$

THE STORAGE BATTERY IN TELEGRAPH WORK.

BY MAURICE BARNETT.

About four years ago the Western Union Telegraph Company introduced at its office No. 70 Broadway, New York, a single storage cell of the "chloride" type to operate the local circuits of that division. This was the first attempt of the Western Union Company to replace primary by secondary cells. By July, 1895, this company had introduced into its service 3116 "chloride" storage cells, thereby displacing 20,407 primary cells—since which time the number of storage cells has been very largely increased.

What is true of this company has been true of other telegraph concerns. Indeed only last year one of the largest manufacturers of fire alarm and police telegraph apparatus in this country, decided to introduce storage in place of gravity cells in all new plants installed by them and to recommend the substitution in existing plants employing primary cells. Again, in railway telegraph work where the conditions are very favorable for the use of secondary cells, the storage battery has met with marked favor. From all of which it would appear that not only has the storage battery gained a substantial footing in a sphere where the primary battery once held undoubted sway, but threatens, in the near future to usurp that entire field.

That which has brought about the above condition is the marked superiority of the storage over the primary cell for this class of work. What makes the former preferable is (1), their lower first cost; (2), their lower maintenance cost; (3), the smaller floor space required by them, and (4), their more satisfactory performance in service. These points will now be briefly discussed.

To arrive at the relative first cost of these cells the best method is to take, in a given number of telegraph offices, the cost of the storage cells in use and compare that with the cost of the primary cells they displaced. In a preceding paragraph it was stated that in July, 1895, the Western Union Telegraph Company had 3116 chloride storage cells in use. The cost of these was between $8400 and $8500. The cost of the 20,000 primary cells which were displaced, was $10,203.50. Figuring in the element of freight would make the difference still more marked in favor of the storage battery. Of course, additional expense is incurred in installing storage cells as special apparatus is usually needed to reduce the voltage of the charging current to the requirements of each installation; recording instruments, charging and cut-out switches will likewise increase the cost of storage battery installation. Inasmuch, however, as the cost of this accessory apparatus is, as a rule, not more than 15 per cent. of the cost of the battery, while the cost of "stands" is very small compared with those needed by primary cells, it is evident that a comparison of the cost of the two classes of cells is in favor of the storage battery.

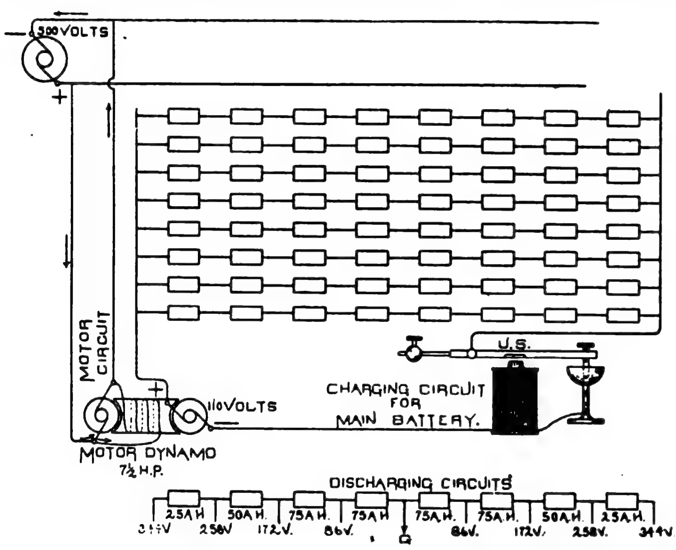


FIG. 1.—ARRANGEMENT OF STORAGE CELLS FOR LONG-DISTANCE WORK AT ATLANTA, GA.

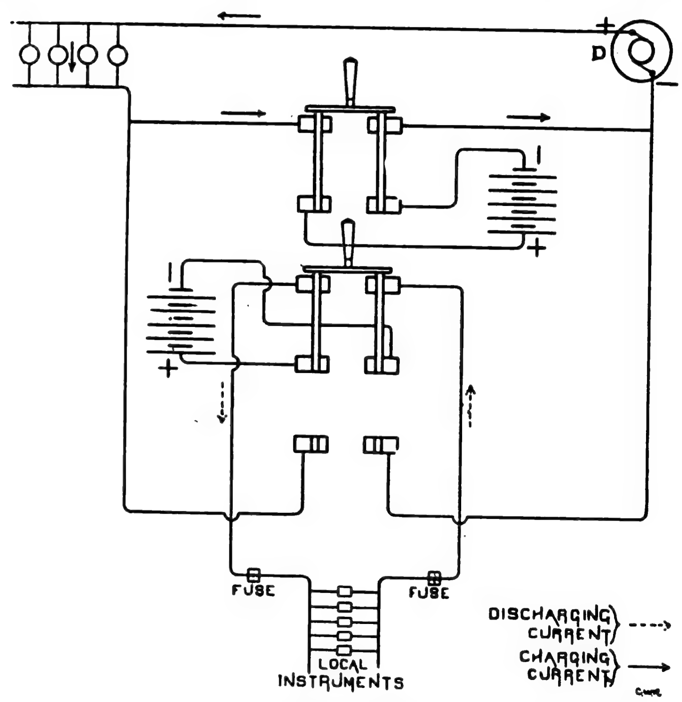


FIG. 2.—ARRANGEMENT OF STORAGE CELLS FOR LOCAL WORK AT BROOKLYN, N. Y.

With regard to the annual cost of maintaining primary and secondary cells, the advantage is still more on the side of the latter. There are differences of opinion as to the cost of material consumed yearly in a gravity cell. Mr. Wm. Finn, who has published some valuable data on this subject, puts this figure at $1.10 a year. J. B. Stewart, Superintendent of Telegraphs of the West Shore Railroad Company, puts the figure at $1.65. Some data in the writer's possession would seem to fix the cost at $1.50 a year, which is probably not far from correct; this includes interest and depreciation.

The cost of maintaining storage batteries is made up of three items: (1) the cost of the charging current; (2) the interest on first cost, and (3) depreciation of cells. In most installations the cost of the charging current is not considered, as it is furnished by the lighting plant owned by the telegraph company. Speaking of this, Mr. C. F. Annet, Superintendent of Telegraphs of the Illinois Central Railroad Company, Chicago, says: "The current absorbed by the charging batteries is not enough to materially affect the light given by the lamps, and as it is furnished by our own lighting plant, the cost is hardly sufficient to justify the estimate." As all the telegraph companies do not possess their own lighting plant, the cost of charging current must be taken on the basis of what an electric lighting company would furnish it for. It is easy of demonstration that this cost is 9 cents a year. Adding 2½ cents for interest and 2½ cents for depreciation we get 14 cents as annual cost of maintaining a storage cell, the equivalent of a gravity cell. As this is less than one-tenth the cost of maintaining a gravity cell the advantage possessed by storage batteries from point of view of operating expenses is quite apparent.

Without going too much into detail regarding the floor space required by the two classes of batteries, it will suffice to say that the storage cell, for a given output, has but one-tenth the cubic volume of a gravity cell. As a case in point, in one of the West Shore Railroad telegraph offices a gravity battery, consisting of 238 cells, required a room 12 ft. × 12 ft.; the present storage battery which displaced it, consisting of 70 cells (chloride type), is placed in a box 5 ft. × 4 ft. × 10 ins. deep.

Lastly, the storage battery is superior to the primary battery for the following reasons: First: Any number of local circuits may be

worked off a single cell of sufficient capacity without irregularities on one circuit being introduced on others. This cannot be done with primary cells owing to their high internal resistance. Second: The internal resistance of a storage battery is practically constant; the output of such cells is consequently constant, an important consideration in telegraph work. Third: With storage batteries no trouble is experienced from excessive evaporation of the electrolyte and from creeping salts—two difficulties always met with in using primary batteries. Fourth: The only attention required by storage batteries is to see that they get the proper charge and that the electrolyte lost by decomposition is made up monthly. Primary batteries require almost incessant attention.

In introducing storage batteries on local and main line circuits, the first thing that must be known is the number and capacity of the cells required. To determine the capacity, in ampere hours, the battery should have for local work: *Multiply the number of instruments by current required by each and the product by the hours battery is to be worked on a single charge.* For the number of cells in series: *Multiply resistance of each instrument by current required to operate it and divide product by two.* For main line work the rules are practically the same. In both cases it is well to allow a small margin both in number and capacity of cells, above what is required by theory. This will safeguard against disturbances on the line and, especially, against the variations which arise in daily work.

In speaking of the relative first cost of primary and storage cells, mention was made of certain auxiliary apparatus needed in installing the latter type of battery. What this apparatus will be will depend upon the conditions prevailing at the battery station. Thus, suppose the only charging current available were one from an alternating machine. As storage batteries must be charged by a direct current, it would be necessary to interpose in the charging circuit some style of transformer to rectify the current and reduce the pressure to the requirements of the station; or an alternating-current motor could be used to drive a small dynamo with which the battery could be charged. A condition frequently met with is one in which the current must be taken from a trolley circuit at 500 volts. In cases like this, especially where it is desirable to economize current, motor-generators are frequently used; otherwise dead resistance could be inserted either in the shape of wire or a bank of lamps. If, lastly, the voltage of the charging current is but slightly above what is needed, the pressure may be reduced by inserting counter E. M. F. cells in the charging circuit. These cells consist of plain lead plates immersed in dilute sulphuric acid of sp. gr. 1.10. On passing a current through such cells a reverse E. M. F. of 2 volts is set up for every such cell in series. Although it is not necessary, many companies employ two sets of batteries so as always to have one as a reserve, charging, while the other is in use. To throw these, alternately, into the charging and discharging circuits a double-pole, double-throw switch is used. Lastly, to prevent the battery from discharging through the armature of the dynamo and running this as a motor, which would happen if the voltage of the charging current should fall below that of the battery, recourse is had to an automatic cut-out switch. This consists of a magnet with its armature. At one end of the armature is a U-shaped wire with ends projecting downwards and dipping into mercury cups which form part of the circuit. If the pressure of the charging current should fall below that of the battery, the magnet will exert only a slight attraction on the armature, which will be overcome by gravity acting on the heavy end of armature. When this is released, the circuit is immediately broken by the wire rising out of the mercury cups—the action taking place before the back pressure from the battery will have renewed the magnetic attraction on the armature. With this explanation some characteristic installations of storage batteries for telegraph work may be briefly referred to, local circuit work being considered first.

One application of storage batteries to local circuit work is seen in the Atlanta office of the Western Union Telegraph Company. Here there are two sets of cells, three cells to a set, of which one is used on the circuits while the other is being charged. These cells are all charged and discharged in series, the cells on discharge being connected on the three-wire system. The charging current is derived from a 1-HP motor-generator, which delivers current at 16 volts and is run as a motor from the 500-volt circuit of the Georgia Electric Light & Power Company. (See Fig. 3.)

At the Lehigh Valley Railroad Company's office at South Bethlehem, Pa., the charging current is obtained from a small C. & W. dynamo furnishing 20 amperes at 6 volts. This is run by an alternating-current motor which is supplied with current by the local power company. In this case only two cells are employed, the dynamo furnishing power on the circuits and charging the batteries at the same time. This dispenses with the use of an extra set of cells. While this is the cheaper method of working storage batteries it does not offer a reserve against accident to the generating machinery. The more usual method is that employed by the Western Union Telegraph Company at its Brook-

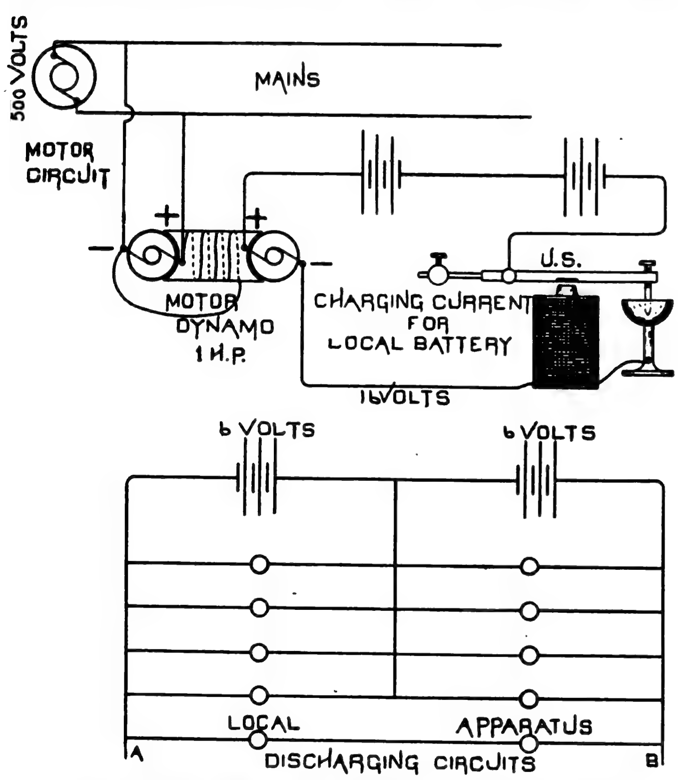


FIG. 3.—ARRANGEMENT OF STORAGE CELLS FOR LOCAL WORK AT ATLANTA, GA.

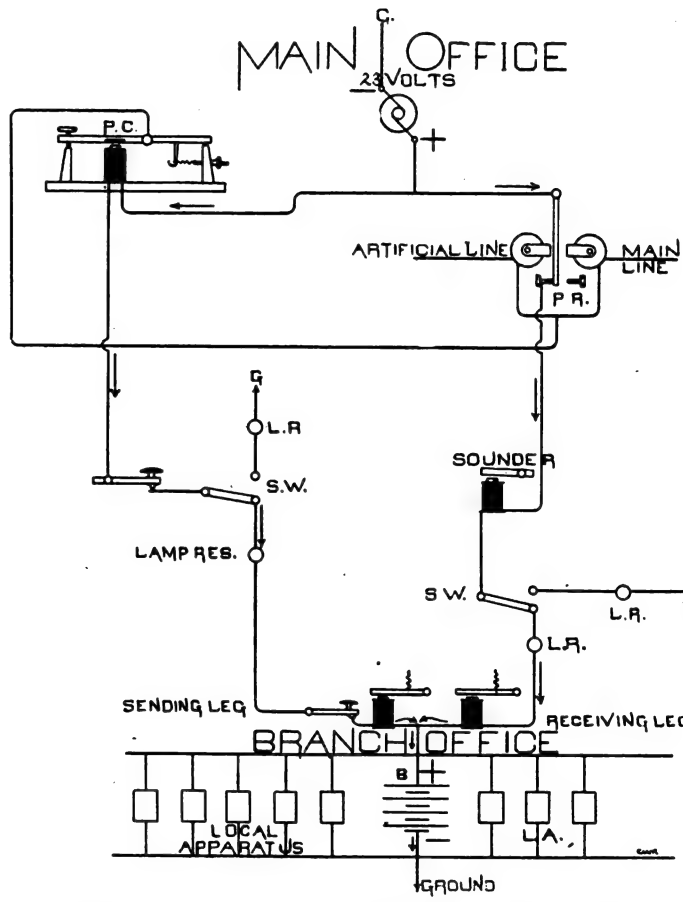


FIG. 4.—ARRANGEMENT OF STORAGE CELLS IN "LOOP" OFFICES.

lyn office. There two sets of cells are in use for local work. By shifting the position of the switches either set can be placed on the circuits while the other is placed as a reserve in charging. In the plant just referred to the pressure of a 110-volt circuit is reduced to requirements by lamp resistance. (See Fig. 2.)

Another interesting application of storage batteries to local circuit work is that in connection with the running of important "loop" offices—which are operated from the main office by means of a small dynamo. Before storage batteries were used in this connection, the current from the dynamo, after being used on the instruments, would go to waste through the ground wire. Now, however, it is the practice to pass this current through a storage cell before grounding it—which results in the storage cell acquiring sufficient energy to operate other local apparatus connected with the branch office—a work which formerly required many primary cells. This arrangement of circuits for loop offices is illustrated diagramatically by Fig. 4.

The large battery plant used by the Western Union Telegraph Company, at its Atlanta office, is an example of the more pretentious installations of storage cells for long distance work. This plant comprises 344 cells of 75 ampere-hour capacity, 72 cells of 50 ampere-hour capacity and 172 cells of 25 ampere-hour capacity. These cells are arranged in two series so that one is in use while the other is on the charging circuits. Each series consists of 43 cells, each of which is charged in multiple-series and discharged in simple series. As indicating the flexibility of the battery system, it may be mentioned that from the same battery it is possible to obtain different voltages to operate different circuits, the only requirement being to tap the battery at the proper points. Thus, in Atlanta, the battery is made to yield, during discharge, four different potentials—86, 172, 288 and 344 volts, these being used on four separate circuits. The current for charging these cells is obtained from a 110-volt motor dynamo run as a motor from a 500-volt power circuit. The 700 storage cells in the Atlanta installation displaced over 8000 primary cells. The arrangement of circuits of the Atlanta plant is shown in Fig. 1.

Another large installation of storage cells is that in the Washington office of the Western Union Telegraph Company. There 724 "chloride" cells are performing the same work which formerly required 7300 bluestone cells. The Western Union Company has, also, large storage battery plants in opera- at Long Branch, N. J.; Easton, Pa.; Bridgeport, Conn.; New York City, and Mauch Chunk, Pa.

At small stations where there is no charging current available it would seem as if it were indispensable that primary cells be employed. It is a question, however, whether even in these stations it would not be cheaper to send out charged storage cells and collect these from time to time. Although the handling would neutralize the economy resulting from their lower maintenance cost, they would render far more satisfactory service than it is possible to get with primary cells.

A PRACTICAL EXPEDIENT.

BY "PRACTICAL."

The following is an experience which occurred to the writer some years ago, and is given as a help to fellow readers who may encounter similar conditions. While it does not indicate the many uses to which series motors may be put, it emphasizes very forcibly, at least, one use to which they may not be put. The incident occurred in a Western city of note, one of whose supporting industries is a gold and silver smelting and refining works.

In this works was a small engine, which was used to run an ore sampler by day and an arc machine by night. This engine broke down; with the prospect created of, not only delaying production by stopping the sampler, but of plunging the works in utter darkness and jeopardizing the lives of the men whose duties lay among vats of molten metal, something had to be very quickly done. The electrician in charge was also electrician of a neighboring electric railway, and he promptly conceived the idea of temporarily replacing the engine by a motor. There being no stationary motor of sufficient size available, a 15-HP street car motor was pressed into service.

This motor was of the old style type, with field sections in series and no means for commuting them, so the field was relatively strong. An overhead wire was run from the street trolley, and the motor was connected, as shown in Fig. 1, where $T T$ is the trolley

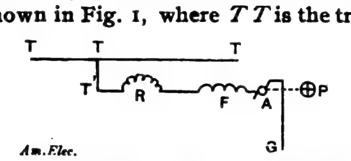


FIG. 1.—ORIGINAL MOTOR CONNECTIONS.

wire, $T T'$ the overhead wire run into the engine room, R an ordinary T.-H. coffee-mill rheostat used in starting, F, the motor field, A, the armature, G, the ground, and P, the pulley on the countershaft to which A, the sampler, and the dynamo were belted. A's pulley was so selected that at full load and 500 volts, A should have turned P at proper speed. But the fact is that at no load the motor would race, and with the sampler on, the speed would fall till the sampler was useless, and if the dynamo were on, the lamp carbons would just jump up and down. Thinking, perhaps, that the motor was too small for the work, Mr. L— borrowed from the railway company one of several modern type 30-HP street railway motors, then in course of installation, and put it in place of the smaller motor.

This motor held up better under load, but

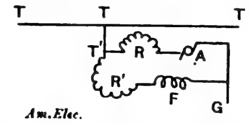


FIG. 2.—MOTOR CONNECTIONS, AS CHANGED.

not well enough to satisfy the conditions. The possibility was then suggested that a poor ground return might cause the E. M. F. to drop under load, thereby dropping the speed. This surmise was disproved by taking the drop on the motor at no load and at full load; the difference was only 30 volts.

The following plan was then adopted, as shown in Fig. 2, where $T T$ is the trolley wire, as before, and $T T'$ the wire leading to the engine room. R is the rheostat in series with armature, A, and R', a second rheostat in series with field, F. Rheostat R', was closed first, so as to put a field on the motor, and was so adjusted as to send about full load current through F. Then to start the motor, R was closed; it could be slowly worked out till it no longer consumed any work, when the entire drop would take place across A. When the sampler or dynamo, as the case might be, was thrown into service, the speed fell perceptibly, but was readily restored to its proper value by working more resistance into R', thereby weakening the field, reducing the field magnetism, hence counter E. M. F., and raising the speed. The motor ran satisfactorily under this arrangement for several days; in the meanwhile the old threshing machine had given way to a new engine.

The explanation of all this strikes the writer as follows: Street car motors in American practice are series-wound and most of us have observed the fall in speed when the car ascends a grade. Now, this will take place whatever may be the type of the motors or their winding, because, all other conditions remaining the same, it takes more current to send a car up a hill than to send it the same distance on a level. Of course, if we stop at the foot of the hill and change gears, wheels, armatures, fields, or any of those things which modify the counter E. M. F. of the armature, we can get a combination that will take the car up the hill with very little current, but the time consumed will be proportionately longer.

Assuming a car to run on a level at a uniform speed, if that car strikes an up grade the speed diminishes, because the motors are called on to do more work and hence to take more work from the line, and since the line voltage is kept the same, the motors must take more current. In order for the motors to take more current, the speed must fall (unless the field is weakened, which we assume not to be the case just at present), for if the speed remains the same the current does also for given voltage and we would have a car climbing a grade with the same rate of expenditure of energy and at the same speed as on the level, which we know to be impossible.

Again, if the speed remained the same, so would the counter E. M. F., and the line voltage could not force any greater current against it. Therefore, the speed must fall so as to lower the counter E. M. F. and let in additional current enough to take the car up the hill. On series motors, however, this discrepancy in free and loaded speed is much greater than on separately excited or shunt motors, because the field and armature are in series, and any increase in armature current is also an increase in field current, which strengthens the field and further reduces the speed.

Now on a shunt motor (of which Fig. 2 gives practically the connections), the field and armature are independent circuits, so that the field-strengthening effect of the series motor is absent and the decrease in speed not so great. In fact, on the shunt and sep-

arately excited motor run from constant potential circuit, the decrease in speed is measured by the increased armature drop due to increased current, so the motor actually runs from a less difference of potential when loaded than when free. As we saw above, the motor speed did drop with the introduction of load, but was restored to its former value by weakening the field independently of the armature. Of course, care was observed to avoid short circuit and injury to F by cutting out too much or all of the resistance in R'.

MICROPHONIC TELEPHONIC ACTION.

BY EMILE BERLINER.

In reply to your inquiry with regard to the experiments on loose contacts made by Professor Fessenden and Messrs. Ross and Dougherty, I beg to say that I have never found occasion to change the view taken by me in 1879, that the variable resistance at a loose contact is due to the variation in the thickness of the layer of air or gas between the two electrodes in so-called contact.

This layer of air was at the time found to be of about $\frac{2}{10}$ ohm resistance in a well adjusted Blake transmitter, when the air was withdrawn by a common air pump. Other experiments showed that at a contact between two carbon electrodes, rigidly mounted, the resistance could be readily adjusted to 20,000 ohms without break, and the late Moses G. Farmer told me that he had succeeded in obtaining an adjustment, giving a contact of a megohm resistance.

The reason why carbon is so well adapted for the microphonic action is very probably due to the fact that it has, in an eminent degree, the property of condensing a cushion of air on its surface. Goldplate a carbon contact, however delicate the coat, and the microphonic action is immediately greatly reduced.

One can get first class microphonic results from all metals, even platinum, provided that the vibrations are of sufficiently small amplitude (very thick diaphragms) and provided that a sliding motion on the contact is avoided.

One of the simplest of microphones is a Morse key with the original spring removed, and adjustable by a relay spring from above.

What is commonly known as a loose contact always includes more or less air between, and as the contact pressure is increased, the air is pushed aside and the difference in resistance becomes less proportionate to the pressure applied.

NOTES.

Municipal Ownership.—An item to the effect that Owatonna, Minn., is a convert to the idea of municipal electric lighting, we find to be untrue. On the contrary, the council of that town has repudiated that doctrine by giving to the local central station a four-year's contract for street lighting by 1200-CP arc lamps.

Röntgen Ray Burns.—Professor Kaposi, an authority on diseases of the skin, is of the opinion that the effects of the Röntgen rays are similar to those of the sun's rays. There is at first an active filling of the blood vessels of the exposed region and this is followed by their paralysis. These disturbances of the circulation lead to an inflammation of the skin, which in turn causes a falling out of hair. After the skin has resumed its normal appearance and function the hair grows out again.

Italian National Exhibition.—From a circular just received we learn that on the occasion of a national exhibition to be held from April to October of the present year at Turin, to celebrate the 50th anniversary of the proclamation of the Italian Constitution, exhibitors from all countries will be admitted to the department in electricity, which will be one of the main features. The circular is signed by the late Prof. Galileo Ferraris, who was president of the Electrical Commission of the exhibition.

Texas Gas and Electric Light Association.—The third annual meeting of the Texas Gas and Electric Light Association will be held Mar. 19-21 at San Antonio, Tex. Among the papers to be read are the following: "The Commercial Efficiency of the Incandescent Electric Light," by H. L. Monroe; "The Storage Battery as an Adjunct to Small Electric Light Plants," by W. L. Hall; "Operating Expenses of Electric Light Plants," by J. D. Oliger; "Electrolytic Deterioration of Water and Gas Mains," by W. A. Frazer. Mr. F. R. Starr, Jr., of Gonzales, Tex., is secretary of the Association.

Chicago School of Electricity.—A committee of the Chicago Electrical Association, appointed at the request of the Chicago School of Electricity, and consisting of Mr. W. Clyde Jones, Mr. Albert Scheible and Mr. E. J. Swartout, has made a very favorable report concerning that institution. After enumerating the methods of teaching and the courses of study the committee concludes with the statement that it believes, as the result of its investigation, "that this school, as at present instituted, should fill a decided need in imparting the elementary knowledge needed by many for the intelligent pursuit of their every-day work, and we believe that the school will do this most fully if accorded the encouragement which it deserves for this purpose."

A Light of the Future.—In a paper recently read before the Chicago Electrical Association by Mr. M. A. Edson, he referred to a method of illumination which, though it may be entirely hypothetical, would be, he considers, the crowning achievement of the century, if realized. Briefly, the method consists in the use of some substance which, when subjected to a high-frequency low potential, will emit light, and is also capable of being mechanically or chemically mixed with pigments used in the manufacture of wall paper, each side and the ceiling of a room covered with it to be separately controllable. This substance should be of such a nature that when mixed with a color it will be invisible by sunlight and allow the true color of the pigment to show, but when subjected to a high-frequency low potential will show the color in its true value, the amount of light emitted to be ordinarily at the rate of about 1 CP per square foot. The details of such a system, Mr. Edson states, are at present obscure, but by electro-chemical means, he believes, a new field of research may be opened, and the attainment of such a system thereby rendered possible in connection with improved appliances for obtaining rapid electrical impulses of considerable power.

Electrical Engineering Literature.—The past few months have witnessed some unusually important additions to electrical engineering book literature. Steinmetz' "Alternating Current Phenomena," Bell's "Power Distribution of Electric Railways" and "Electric Power Transmission," and Kapp's "Transformer," are all treatises of the greatest engineering value, and each is a much-needed addition to the branch of which it treats. Another book of similar value, now in press, is Wiener's "Practical Calculation of Dynamo-Electric Machines," and mention should not be omitted, in view of the growing recognition of the importance of electro-chemistry, of the lately-issued translation of Le Blanc's "Elements of Electro-Chemistry," though this latter work is of a different character from the above, dealing with theory rather than with practice. The books first named, together with Crosby & Bell's "Electric Railway," Parshall and Hobart's "Armature Winding," Crocker's "Electric Lighting," and Thompson's two books on electrical machinery, cover the field of electrical engineering in a passably complete manner, but there remains a crying need for a work in the English language on electro-chemistry similar to that of Ostwald or Borchers in German. It is to be hoped that an English translation of one of these works will soon appear or, better, of both, as one complements the other.

Du Bois-Reymond.—Emil Du Bois-Reymond was born Nov. 7, 1818, in Berlin, whither his father had emigrated from Neufchâtel, Switzerland. After completing his preparatory studies at the Collége Français in Berlin, he studied philosophy and natural sciences at the Universities of Berlin and Bonn, returning from the latter to Berlin, where he studied medicine. Through his death, science, and especially biological science, has lost one of its most prominent and popular representatives. For a number of years professor of physiology in the University of Berlin, and secretary of the Academy of Sciences, he had founded a new school of physiology which, by its physico-mechanical tendency, brought about a complete revolution in biological science. Cofounders of the same school were Brücke, Helmholtz and Ludwig, all of whom have died within the past five years. Du Bois-Reymond was a man of wide learning, as his numerous literary labors in physiology, physics and philosophy testify. His greatest achievements were his experimental researches in electro-physiology, conducted in 1841-1848, the results of which were published in two volumes. This classical work, on "Animal Electricity," attracted considerable attention in the scientific world. A number of electrical appliances used in experimental physiology are of his device, and the induction coil which goes by his name is in general use in electro-medical apparatus.

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Rating of Dynamos and Motors.

A correspondent asks whether a machine will have the same capacity as a motor as its rating as a dynamo; or to put the question in a specific form, Will a 10-KW 110-volt dynamo have a capacity of 10 KW when run from a 110-volt circuit? Obviously not, for the reason that as a dynamo the losses between the driving power and the binding posts are not accounted for at the binding posts, while on the other hand, these losses in the case of a motor are subtracted from the energy delivered at the binding posts. In order for the motor to develop the same power, it must be run from a circuit of higher voltage, in which case a greater current will pass through its armature, the increase being that required for torque in overcoming effects that in the case of a dynamo add to the torque of the source of mechanical power. It will be not far wrong to give a motor the same numerical rating in horsepower that the same machine as a dynamo has in kilowatts, if the voltage at the binding posts is the same in both cases.

Electricity and Burglary.

The article by Lieut. Rodman in other columns on "The Application of Electricity to Bank Burglary," illustrates anew the fact that the progress of science does not confer unalloyed benefit—that the new powers with which it endows man are capable of ill as well as of good use. In order for the cracksman to use the electrical method of burglarizing described, he would have to be an electrician of very considerable skill. This conclusion, however, contains little consolation, for the art of burglary as at present practiced also requires skill of a high order, and the supply has always been equal to the demand. Security is ensured against burglary becoming an electrical profession by the conditions that would hamper its exercise. Even if there were a sufficient source of electrical current, the great draft that would have to be made upon the circuit tapped would prove a drawback in most cases, necessitating direct connection to terminals or access to fuses, in either case apt to be unfavorably located for the purpose in view. We understand that one result of the demonstration of the feasibility of the new method of burglary described has led to the further development of the electrical protection of safes, whereby they are rendered secure against this or any other form of attack.

Electricity from Carbon without Heat.

A recent discussion on the above subject before the American Institute of Electrical Engineers calls to mind a chapter in the late J. E. H. Gordon's "Treatise on Electric Lighting," consisting of the single sentence, "Little or nothing is yet known on this subject," or words to that effect. Some of those who took part in the discussion referred to enlarged upon the inefficiency of the steam engine, and mourned that we cannot successfully emulate the animal organism in its highly efficient transformation of the energy of carbon into useful work. To be sure, the barrier interposed by the inexorable second law of thermo-dynamics to the increase of the efficiency of the steam engine, was referred to, and it might have been added that we cannot expect to find much of a guide for future developments in the subject discussed, from physiological actions into which the divine factor of vital force enters.

The problem at issue is simple enough of statement. We know that when a pound of carbon unites with oxygen, in the act of combustion about 14,000 heat units of energy appear in the form of heat. As we also know that all forms of energy are interchangeable—that heat can be turned into electricity and electricity into heat—it follows that there is no physical reason why this energy of carbon should not be transformed as directly into electricity as it is now into heat. What is being sought for is the mechanism of the desired transformation, and in this respect the discussion added nothing. One reason for the negative results of experiments thus far undertaken to solve the problem appears to be that the differentiation of the several factors that have entered has been neglected. Even so great an authority as Borchers a few years ago fell into this error, having hastily announced a solution of the problem of "electricity direct from fuel," when it was subsequently shown by Reed that the results produced could be accounted for by simple galvanic action; and a widely heralded recent discovery of the same kind appears open to the same criticism. It is possible that the separation of the several factors entering may be a matter of difficulty, but until the subject is approached in a manner more in accordance with modern scientific methods than it has in the past, negative results may continue to be expected.

Microphonic Telephonic Action.

In another column we print a communication from Mr. Emile Berliner on the cause of michrophonic telephone action, which subject was the occasion of an article by Prof. Fessenden in our February issue. As will be seen, Mr. Berliner takes direct issue with the theory that in recent years has received wide support, and ascribes the microponic action as due to the variation in the thickness of the layer of air or gas between the two electrodes, which latter are not supposed to be in actual molecular contact.

The theory controverted is that the variation in resistance of electrodes is merely due to a variation of the number of molecules in contact, and that therefore the Berliner microphone patent is covered by the Bell liquid telephone patent of 1876.

There have been four explanations of microphonic action put forth—the two above stated and those of Edison and Hughes. Edison maintained that the variation of resistance was due to variation in the pressure to which the carbon electrode of his patent was subjected by the vibration of the diaphragm acted upon by sound waves. This view of the action was in accordance with the earlier experiments of Du Moncel and Clerac, among others, who found that the resistance of carbon varied with the pressure to which it was subjected. Hughes formulated a somewhat intangible theory of the "microphonic joint," and showed that pressure was not the controlling factor, for the reason that speech is best transmitted in a given instrument at a given pressure, the articulation becoming poorer if this pressure is made greater or less, and finally ceasing at a limit on either side.

The theory put forth by Mr. Berliner appears to include that of Prof. Hughes, and in addition gives some explanation of the actual mechanism of microphonic action. Its weakness lies in the fact that it is based upon assumed conducting properties of the intervening thickness of air or gas, or, at least, postulates properties that have not received scientific proof. The later theory put forth by Mr. Dunbar, Prof. Fessenden and others, has in its favor accordance with well recognized principles of electrical variation of resistance—in fact, having been the basis of the original telephones of Bell and Gray. The question, however, would appear to remain an open one until it has been decisively determined, one way or the other, whether a layer of gas or air does intervene in microphonic action, since the "variable area of contact" theory can be true without affecting the truth of the former.

Induction Coils.

From the many queries received on the subject, it would appear that the principles applying in the design of the primaries of induction coils are little understood. The E. M. F. of the secondary is produced by the sudden withdrawal of the lines of force introduced into its circuit by the primary winding. The latter, therefore, should be so designed as to supply the necessary number of these lines and also to permit of their rapid withdrawal. The number of lines of force depends upon the ampere-turns in the primary. On the other hand, the less number there are of turns in the primary winding, the less will be the sparking, due to inductance, at the circuit breaker; and, therefore, the quicker will be the withdrawal of the lines. It follows that the ideal primary would be one with but a single turn of wire and a large current, for we could thus obtain the requisite number of ampere-turns and at the same time reduce the inductance to a minimum.

In practice, the primary current should, therefore, be the largest that can be carried without undue heating, and the number of the turns should be kept at a minimnm. If a source of high voltage is to be used, the coil should not be wound with small wire in order to adjust the current to what may be thought a necessary strength, as this will introduce undesirable inductance. The principles above mentioned should not be disregarded in any case, and in that in question what resistance is necessary should be introduced in circuit outside of the coil. If the resistance is in the form of wire it should be wound zig-zag rather than in the form of a coil, or, much better, incandescent lamps, used as resistance, on account of their inappreciable inductance. The resistance thus introduced will, instead of acting injuriously as it would if wound on the primary core, actually improve the working of a coil over a similar one supplied from a source of low voltage, by reducing the time-constant—that is, increasing the rate of discharge.

It may here be added that it is useless to make calculations of the primary coil on the basis of the resistance of its windings, since inductance is the controlling factor in determining the amount of current that will pass, and may make it a matter of almost indifference if a coil is wound with No. 14 or No. 18 wire, provided the turns are the same in both cases. The point to be observed in selecting the size of wire is merely that it shall be sufficiently large to carry the given current without unduly heating the primary when in place. To resume, the rule for primaries is to use large currents and few turns and to adjust the current to the supply voltage by means of non-inductive resistances in exterior circuit.

The Henry.

When inductance first began to assume a position of some importance in practical work, it suffered the misfortune of having a most barbarous name applied to its unit of measurement—the secohm. While this unit has the same dimensions as the unit of resistance, what connection there is between it and an ohm per second—if that is what the name implies—it is impossible to see. Later the name of quadrant was applied to the same unit "to be expressed in centimetres," and so expressed, it becomes one billion centimetres. The connection between centimetres and a phenomenon whose effect is measured in volts did not make this nomenclature any improvement on the former. Finally, at Chicago, the name henry was adopted to designate the unit of inductance, and its definition was put in terms of the volt.

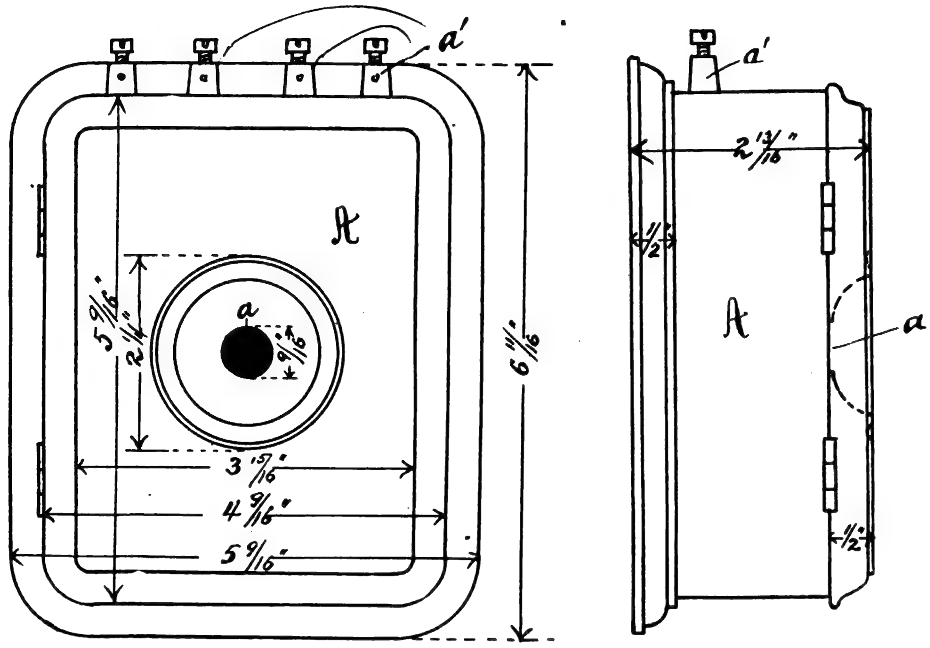
Suppose that we have in a circuit, such as a coiled conductor, a current of one ampere flowing, and that, if the E. M. F. is short-circuited out or otherwise removed, one volt will be maintained for one second by the magnetic discharge of the circuit; the circuit will then be said to have a self-inductance of one henry. In order, however, for one volt to have been maintained in the circuit for one second, the circuit must have included such a number of lines of force that multiplied by the number of turns in the circuit would give a product of 100,000,000 cuttings—a volt being produced by 100,000,000 lines per second cutting a conductor. We thus have two definitions of a henry, one in terms of a uniform variation of current and the other in terms of the number of lines passing into or out of a circuit per second, the effect in both cases being expressed in volts. If in a circuit having a self-inductance of one henry the current should vary at, say, the rate of five amperes per second, then, since the cuttings of the lines of force would be five times as rapid in order for the five-fold number to pass out in unit time, there would be five volts of inductive E. M. F.

In the case of currents not varying uniformly in value, the inductive E. M. F. can yet be calculated on the basis of the henry, if we know the law of variation. The henry, in fact, refers to the simplest possible case of variation—a uniform variation of one ampere per second—which rate was purposely selected on account of its simplicity. Suppose that a circuit is measured and found to have a self-inductance of one henry—that is, will generate an inductive E. M. F. of one volt if a current flowing through it varies at the rate of one ampere per second. If now a sine wave alternating current of one ampere is passed through the circuit, having a frequency of 100 periods per second, the inductive E. M. F. will be 628 ($2\pi n$) volts, which implies that the cutting of lines of force on the basis of a uniform rate is, owing to the frequency and form of variation, 628 times greater than in the case of one ampere uniformly dying out in one second.

HOW TO MAKE A TELEPHONE.

BY K. E. CLEMENT.

The only thing that prevented Philipp Reis being honored, the world over (as he is today in Germany), as the inventor of the telephone, was the fact that he could not—or those who have since tried cannot—make his first instruments talk. It is said that the difficulty now is to find a microphonic instrument of any kind—his kind included—that will *not* talk. And all the reason in the world is that we know how to adjust a single screw! The very first telephone, made by Reis, was constructed from the bung of a beer barrel and the skin of a German sausage with platinum electrodes. It probably sang and transmitted tones all right, but would not articulate. And yet I have made a telephone from the back of a cigar box with a Waterbury watch spring and a piece of arc-light carbon that transmitted perfectly. The whole secret lies in keeping your electrodes together constantly. This is the only real difference between the Reis telephone and the Blake transmitter, which is in use all over the world and has proved the best all-around instrument on the market.



FIGS. 1 AND 2.—TRANSMITTER CASE.

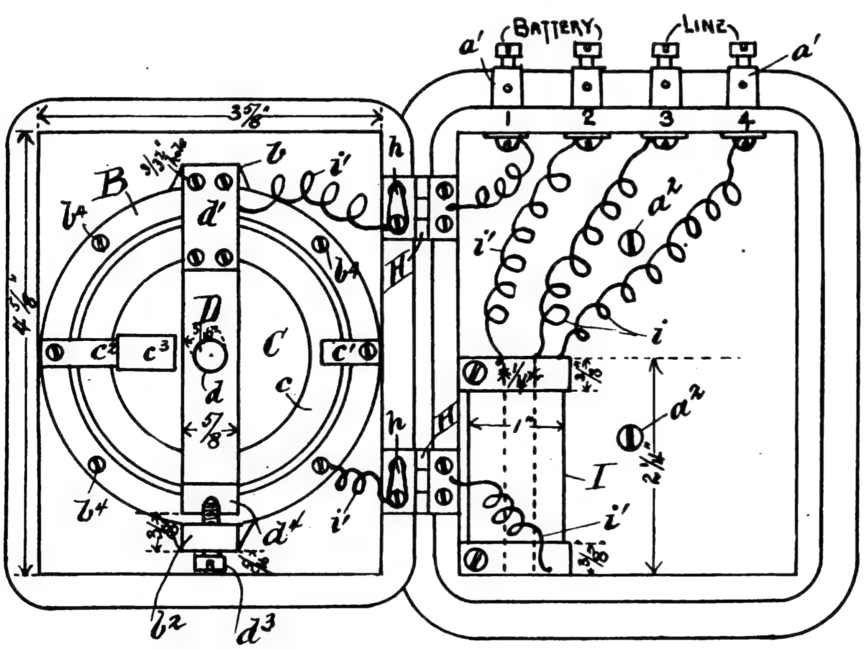


FIG. 3.—BLAKE TRANSMITTER.

In fitting up a telephone line for communication there are four elements necessary at each end—a transmitter, a receiver, a call-sending device, and a call-receiving device. For the purposes of this article I will presume that the telephone line is a short one, say less than a mile in length—perhaps 1000 yds., with a single wire, of iron, No. 12, galvanized. At each station you bring the line indoors to the instrument by connecting office wire at the window and leading it around the woodwork of the room. The joint outside the window must be soldered, the joint taped, and the wire bent down U-shaped before it comes in, to allow moisture to drip off. At your instrument another piece of office wire should be started and led off to the nearest water pipe. The end of the wire should be stripped for 12 ins., cleaned bright, the pipe likewise scraped bright, and the wire wound tightly around the pipe and soldered. If this is done carefully at both ends of the line, you have a good circuit completed over the iron wire from one station to the other and back by way of the pipes and the earth. It only remains to connect your instruments to the wire ends and you should be able to talk perfectly.

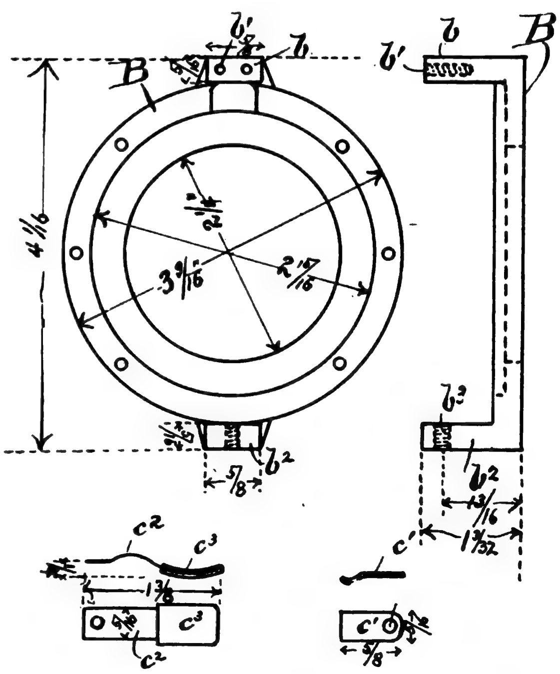
For such a line a push button and vibrator bell, with a battery, at each end, will furnish as good a call as may be. The arrangement of these is indicated in Fig. 10. They can be purchased of any supply dealer more cheaply than you can make them.

For talking, a Blake transmitter and a form of the standard Bell receiver will be found the best. The patents on both of these instruments have expired, and they can, therefore, be made and used by anyone at present.

The Blake transmitter is illustrated in Figs. 1 to 7, and the receiver in Fig, 8. I will describe the receiver first, as you will find you can use it for a temporary makeshift, both to talk and receive, while the transmitter is in process of construction.

First, procure a straight bar magnet of the best tool steel, hardened glass-hard and strongly magnetized (Tungsten steel is preferable). It should be long in proportion to its thickness, in order to maintain its magnetism well—say, ¼ in. thick by 7 ins. long.

Take three-sheet bristol board and cut out two disks, about 1½ ins. in diameter. Thin hard wood disks will also answer. Cut at the center of each a hole of the exact size of your magnet, and slip the disks on one end of the magnet, ¼ in. apart. One-sixteenth of an inch of the end of the magnet should protrude. Wind a single winding of thin paper around the magnet, between the disks,



FIGS. 4, 5 AND 6.—DETAILS OF TRANSMITTER.

for insulation. Then wind No. 36 silk-covered copper wire carefully between the disks until the space is nearly full. In winding, the best results can only be attained by the greatest care. There must be absolutely no kinks or twists in the wire and no breaks in the insulation. A little melted paraffine or a little shellac can be placed over the outside layer to hold the wires, and you should leave several inches of ends for connecting up.

Now take a sound piece of hard wood and turn up a case. In the illustration (Fig. 8) this is lettered *R*. It should be 1 in. in external diameter, except at the large end, which should spread out in a bulbous form, as shown, with a diameter of 2½ ins. outside at the edge. Turn up a cap of the same wood, in the shape shown. Its outside diameter is 3 ins., and it should fit neatly over the end of the case. The cap is lettered *r*. A depression should be turned in the outer face, as at T', and a similar, but shallower, depression, as shown in the inner face. In the center should be a hole, ½ in. in diameter. Drill small screw holes in the side flanges for the screws, r^3.

Through the center of your case bore out a straight smooth hole just large enough to receive the magnet, and at the large end of the case turn the hole out to 2 ins. in width and ¾ in. deep, as shown.

Drill a screw hole for the set-screw, *S*, near the small end of the case. Now slip the long end of the magnet into place. If it proves too loose wrap thin paper about it.

Take a pair of compasses and lay off on cardboard a circle with 1¼ in. radius—to fit exactly between the cap and case. With this as a template scratch a similar circle on a piece of photographer's ferrotype plate—"tintype" plate—which you can buy for a nickel. Cut out the disk with sharp scissors. Take care not to bend it, as this is the reason the compasses are not used directly on it. Any bend or buckle spoils it. This is the diaphragm. Now take two pieces of No. 16 wire, scrape the ends and make a kink in each. Solder the ends of your fine wire coil to them and pass them through the side of the case. They are shown at *w* in Fig. 8. The object of the kink or knot is apparent when you insert them. The knot comes against the side of the case, and prevents any pull coming on the thin wire to break it. Of course, if you want to take the trouble you can cut a channel each side of the magnet hole all the way back to the rear cap, r^4, and put binding posts there. Now put the diaphragm half over the large end of the case, and adjust the magnet until it nearly touches; $\frac{1}{32}$ in. is the proper clearance. Then screw down the set-screw, *S*. Put on the diaphragm (shown at r^2), place the cap, *r*, over it, screw in the holding screws r^3, and glue on a covering disk, r^4, for the rear end, and your instrument is complete.

It is advisable, in making the cap, *r*, to have the inner face over the diaphragm with a clearance of not more than $\frac{1}{16}$ in. If there is too much space between the cap and diaphragm, the sounds received will be muffled. The cap should be firmly adjusted against the diaphragm at the edges so as to clamp it against rattling.

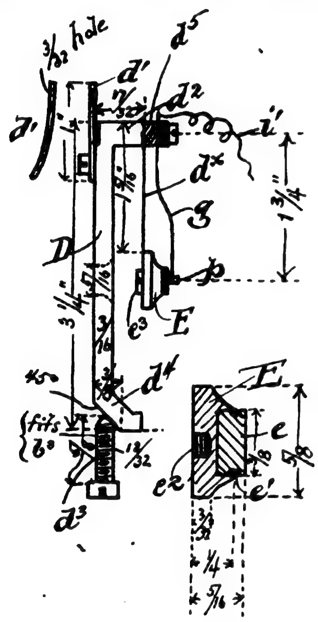


FIG. 7.—DETAILS OF TRANSMITTER.

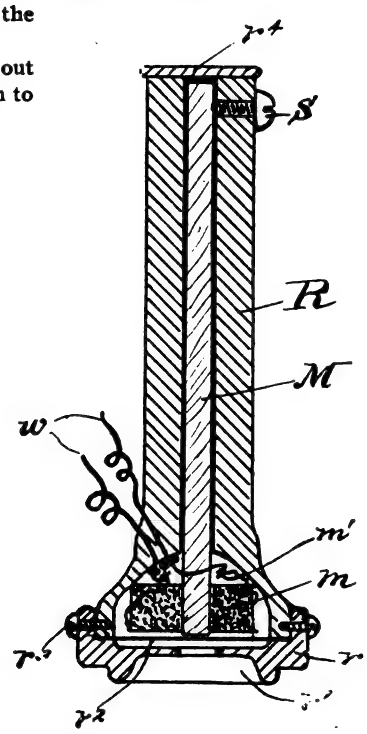


FIG. 8.—RECEIVER.

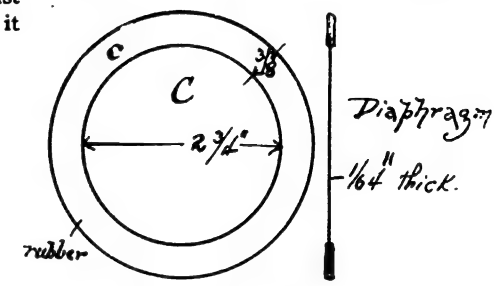


FIG. 9.—DIAPHRAGM.

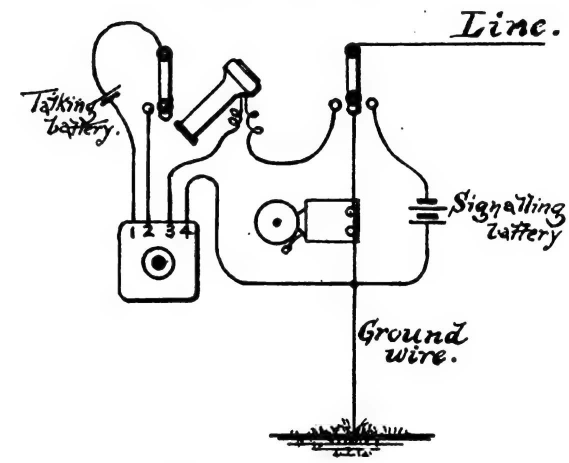


FIG. 10.—CONNECTIONS OF TELEPHONE CIRCUIT.

In making the transmitter the first thing is the case, *A*. This is shown in Figs. 1 and 2. It should preferably be of hard wood, nicely smoothed, filled, rubbed and polished. The door of the case carries all the operative parts of the transmitter and is provided with brass hinges, *H*, which form part of the circuit, so that by simply opening the door you can get at the apparatus without breaking any connection. The mouth-piece, *a*, is simply a depression turned in the door face, as shown in dotted lines in Fig. 2.

The transmitter proper is all carried by the iron ring, *B*. This is best shown, with its dimensions, in Figs. 4 and 5. As seen, it is a flat ring having a circular rabbet or depression to receive the diaphragm, and an upper and a lower lug, *b*, and b^2. It is screwed directly on the inside of the door by screws, b^4. It should be turned up smooth and true, and the extreme thickness of metal may be about ¼ in. on the edge. The upper lug, *b*, is tapped in its face for two screws at b^1, and the lower lug, b^2, is vertically tapped for one, the adjusting screw at b^3. Carried on the upper lug, by the spring, d^1, as shown in Figs. 3 and 7, is the bar *D*, to which the electrodes are attached. This bar has an upper or head lug, d^2, and an inclined foot, d^4. The head lug carries the springs, d^x and *g*, carrying the electrodes, *E* and *p*. These springs are simply clamped to to the head lug, d^2, the first one, d^x, resting directly against the metal, d^2, held on by the insulating block, d^5, against which rests the spring, *g*, clamped in turn by another little insulating block. The screws pass through both insulating blocks and are tapped into metal head lug, d^2. To the spring, *g*, *above* the insulation, is soldered the wire, i^1, forming part of the primary circuit.

In operation, the point, *p*, carried by spring, *g*, rests against the diaphragm, the spring, d^1, however, constantly tending to carry it away; so that by screwing up or down the screw, d^3, the pressure may be accurately adjusted.

The spring, d^x, is of fine spring steel, $\frac{1}{100}$ in. thick and $\frac{3}{64}$ in. wide. Secured to the end, either by clamping under screw head, e^3, or by cutting a channel across and upsetting the edges over the spring, is a brass button, *E*, carrying the carbon electrode, *e*. The way to make this is as follows:

From a solid piece of brass turn up the button of the size indicated, leaving the edges, e^1, very thin and sharp. Cut the carbon button, *e*, accurately and channel around it a shallow groove just where the edge, e^1, comes. Then put the whole in the lathe and spin the edge, e^1, around into the channel so that it tightly embraces the carbon.

The carbon button, *e*, must be pure homogeneous carbon free from grit, and highly polished on the contact surface. The way to get the best polish is to rub the button for a

while on a smooth sheet of the same kind of carbon. As this is not usually available, however, you will probably find most convenient the old reliable emery paper or cloth. Take a piece of fine emery cloth about 6 ins. square and rub your button (which you must leave about ⅛ in. too high when mounting) on the emery, in a 3 in. circle. Keep it moving always in the same direction and after a while the carbon deposited on the emery will form a fine polishing surface, and give you a glass polish. Be sure, however, to use none but the finest emery.

Attached to the spring, *g* (which is of German silver, .005 in. thick, ⅛ in. wide), is the platinum point, *p*. This can best be secured by solder, and should be $\frac{1}{16}$ in. across. A tiny end of platinum wire put through a corresponding hole in the end of spring, *g*, and soldered, is all that is required.

In the bar, *D*, is an opening, *d*, opposite the electrode to permit adjusting. The diaphragm, *C*, rests in the depression in ring, *B*. Around its periphery is stretched a rubber band, *c*, to deaden or dampen the vibrations to some extent. It is held in place by two spring arms, c^1 and c^2, made of flat spring steel, and shown best in Fig. 7. The arm, c^2 extends over the rubber, c^1, being screwed to the ring, *B*, and has a rubber case or tip, c^3, covering the end that rests on the diaphragm. This produces a dampening effect that is very necessary because of the delicacy of the contacts in this form of instrument. The other arm, c^1, simply extends on to the rubber, c^1, and has a clamping action. Both spring arms should press lightly on the diaphragm.

The diaphragm itself is to be made of sheet iron. Ferrotype iron, much heavier than that used for the receiver, is required.

One side of the circuit through the transmitter leads from the iron ring, *B* (to which the wire *i'* is soldered), to the spring, *n*, on hinge, *H*. This spring (one on each hinge) makes a scraping contact with the other leaf of the hinge when the door is shut, and so ensures a good contact there. The other side of the circuit leads from the spring, *g*, to the other hinge. The current from battery enters at binding post 1, Fig. 3, flows to hinge, *H*, spring, *h*, wire *i'*, spring, *g*, platinum tip, *p*, carbon, *e*, brass button, *E*, steel spring, d^1, iron bar, *D*, iron lug, *o*, iron ring, *B*, and wire, *i'*, to other hinge, *H*, the primary of induction coil, *I*, to the second binding post 2, and so back to battery.

The secondary of the induction coil is connected to the binding posts 3, 4. The induction coil itself may be made as follows:

Take a bundle of very soft and fine iron wires, 2¼ ins. long, and enough to measure ¼ in. or ⅜ in. through. Wrap a turn or two of thin tough paper about them, and fit on either end a square block of wood, ⅜ in. thick and 1⅛ ins. on a side. Wind between these blocks and on the paper, about 35 ft. of No. 24 silk-covered wire. The ends should be carried out through fine holes drilled in the wooden end pieces.

Over this primary winding lay on carefully about 600 ft. of No. 38 fine silk-covered wire, and carry the ends out at one end in a similar manner. Cover the coil with a wrapping of binder's paper gummed fast on the edges, and fasten the coil in the position shown in Fig. 3, by two long screws through and through the ends into the back of the case. Carry the ends of the secondary winding to binding post screws, 3 and 4 and solder them. Connect one end of the primary to binding post 1 and the other to the lower hinge, as shown.

In winding it is important to wind in regular layers from end to end, and to avoid the slightest kink or twist in the wire.

The connections of the instrument are clearly shown in Fig. 10. The switches cut off the bell and put on battery, when moved to the right, for calling, and cut in the telephone and close the local battery for talking when moved to the left.

If an outdoor line is used it is advisable to use some form of lightning arrester, which may be obtained from a dealer at small cost, *outside* the instrument.

FAULTS AND HOW TO FIND THEM.

FAULTS IN ARC LAMPS.

The constant-potential arc lamp is one of the most annoying and unsatisfactory lamps that burn and no one has yet produced an arc lamp of this type that is entirely above criticism.

A constant-potential arc lamp is one that burns on a constant-potential circuit. The potential at the terminals is frequently anything but constant. A lamp of this type must feed the carbons properly and, besides that, it must by its feeding control the potential at its terminals, and also the current that it receives. Now, it is easily possible for the current to be just right, and voltage to be too high or too low; and, conversely, the voltage may be what is proper, and the current be entirely too large or too small. The lamp can do but one thing to adjust these values, namely, vary the distance between the carbons, and in one of the cases just recited there can only be a struggle between the bobbins in the mechanism for the control of the armature, and consequently the lamp will flicker and see-saw with its neighbors.

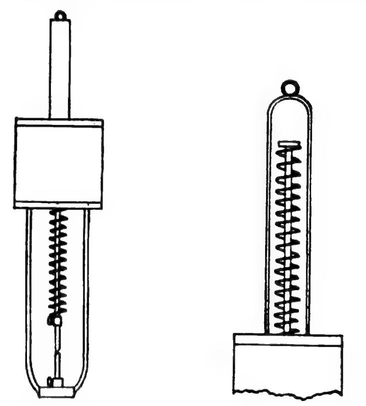
One of the factors of the energy supplied to an arc lamp must be kept constant by outside means. The lamp cannot regulate both of these factors by varying the distance between the carbons. For this reason, arc lamps that are placed on a constant-potential circuit will not operate satisfactorily without a resistance. Its most apparent office is to absorb the extra voltage, but a more important, though less obvious one, is to limit the current so that the lamp has no longer a range in this respect from zero to infinity. The current in an arc lamp can vary from 6 to 15 amperes, and yet the light will be fairly satisfactory. Therefore, such simple and crude regulation of current suffices, and this is all that renders the constant-potential lamp a possibility, at least as present practice has designed it.

In such lamps the series coil, if there is one, should never be allowed to prevail; it should simply be a balance to the shunt coil, and if the lamp is of the open-circuit type, it may be replaced by a suitably adjusted spring. If there are two lamps in series across 110 volts, as is often the case, both will of necessity receive the same current. It is the potential that must be equalized between them and consequently if there is see-sawing, look to the potential bobbins and be sure that they and their balancing forces are in normal condition. If one arc burns too short, tighten the spring that pulls against the shunt bobbin, and if it burns too long, loosen it. A point can be found where the lamps will balance.

See-sawing is sometimes due to unbalanced series coils, which interfere with the equality of the action of the shunt coils. Therefore, they are a nuisance in direct-current, constant-potential arc lamps. In closed-circuit arc lamps, they are necessary, but their only office is to strike the arc. This being done, they only interfere with the potential regulation by interposing an irregular and variable balancing pull on the armature. They respond to variations in current, but as they fail signally in regulating that current to anything like a constant value, they had better be left out altogether, for they interfere with the shunt bobbin in its regulation of the potential.

Unfortunately, the searcher after faults can only correct what exists, and is not a designer of lamps. Therefore, when series coils are encountered and suspected of mischief, they should be tested as follows:

Open the shunt coils of both the lamps and after placing a variable resistance in circuit, note the action of the series coils. They should attract the armature with equal force in each lamp, and if one of them is deficient, look for short-circuited turns in its construction. If this lamp has been burning with a short arc while its mate has had a long one, they may be sought with a reasonable certainty of finding them.



FIGS. 1 AND 2.—FLEXIBLE ROD CONNECTIONS.

When a lamp burns singly on a constant-potential circuit in series with a resistance, this trouble of an unequally divided voltage does not enter, and faults, if any exist, may be sought for and remedied by the rules laid down in a previous article.

Constant-potential lamps usually burn better with a soft carbon above and a hard one below. The reason for this is found in the fact that with these carbons, the arc formed is of such a nature that varying its length more nearly effects the simultaneous regulation of voltage and current, that in the case of a constant-potential arc lamp.

Alternating-current arc lamps are usually of the simplest construction and have but few faults. The voltage supplied them is always kept at a constant value either by means of a special transformer, or an economy coil, which latter is simply a variable

inductance. Therefore, the only factor to regulate is the current, and hence such lamps have a series coil only. The most common trouble is difficulty in starting. The lamp chatters furiously, but the arc does not seem stable enough to follow. The remedy is to use soft carbons that support an arc more easily. If the current were turned on gradually so that the carbons would have a chance to get hot, the arc would be easily formed. Unfortunately, unless the economy coil is adjustable this is not easy to accomplish, and at best is an inconvenient process in practice.

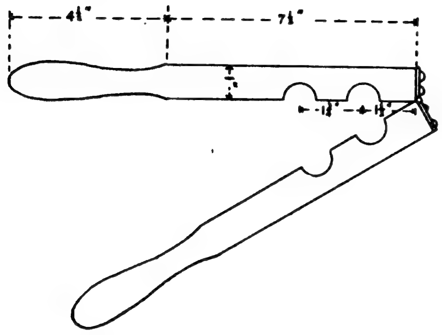


FIG. 3.—ROD POLISHING CLAMP.

The principal mechanical troubles in an arc lamp are easy to locate. Broken or bound pivots and similar difficulties ought to be apparent on inspection. A frequent trouble is a roughened rod, which the clutch often finds difficulty in feeding properly. This trouble is mostly due to sparking at the contact brushes and is usually avoided by polishing with crocus cloth at each trimming.

A permanent cure for this is to make a flexible cable connection to the rod. This is practiced on all modern lamps and may be easily introduced on the earlier types. Fig. 1 shows the easiest plan. A coil of springy copper wire surrounds the rod and descends with it. It is firmly clamped by a suitable screw, with the end of the feed rod, and the other end passes through a bushed hole in the lamp casing and is suitably connected within. The coiled form prevents swinging contacts with parts of the frame, as in the case of a simple loop. The latter device, by the way, is frequently used. When it is desired to clean the rod, the coil is disconnected therefrom, and springs up to the bottom of the casing, leaving the rod easy of access.

This coil is somewhat unsightly, and those that are more fastidious may use the device shown in Fig. 2, and at the expense of a little more labor will secure a neater job. This is practically the same arrangement, except that the coiled wire is contained in the tube that forms the receptacle for the rod when the lamp is newly trimmed. It may be necessary to line this tube with asbestos paper, if this has not already been done. The coil exerts a slight spring tension on the rod, and it may be necessary to alter the weight of the latter to compensate. This, of course, is a matter of experiment.

Those who have many lamps to look after will have a large number of rods to polish and straighten, and will find the following devices very convenient. The use of them is quite obvious, and the drawings are properly dimensioned, and will suffice for their construction. The polishing clamp (Fig. 3) consists of two pieces of wood hinged together. A number of augur holes, the size of the rods to be polished, are bored on the line dividing the pieces when they are closely pressed together in a vise. These holes are lined with crocus cloth. A number of holes lined with polishing cloths of various fineness will be found convenient. The rod to be polished should be spun in a lathe, and the device clamped about it and kept in motion.

The basis of the straightener (Fig. 4) is the main casting, which is not a difficult pattern to make. It should not cost more than a day's labor for the pattern and a dollar or two for the casting. The three wheels, *R R R*, should be of soft brass, in order that they may not scratch the rod. The materials for this device should not cost over three dollars, and the necessary tools are almost always to be found in a shop where arc lamps are tested and repaired.

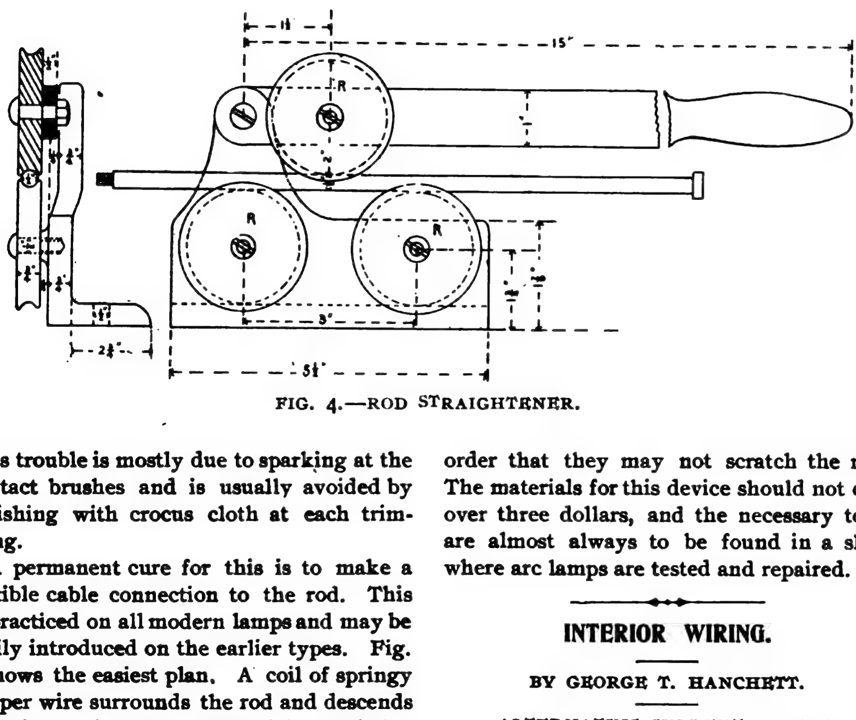


FIG. 4.—ROD STRAIGHTENER.

INTERIOR WIRING.

BY GEORGE T. HANCHETT.

ALTERNATING-CURRENT WIRING.

As some readers may not clearly understand the use of the curves for alternating-current wiring in the February number, several problems will here be given to cover all possible cases.

The first thing to do is to divide the line loss, which is assumed as 4 volts, 5 volts or 10 volts, etc., by the current to be transmitted in amperes, and to divide that result by the distance in feet. The result is the impedance per foot of circuit, and has been designated by *K*. The value of *K* is sought on the vertical scale of the curve and the interaxial distance (that is, the distances between the centers of the wires) is found on the horizontal axis. Thus an ordinate and an abcissa are located and these two lines meet in a point. This point is in the midst of the curves and the nearest one corresponds to the proper wire to use.

The wires that are indicated in the curves cover any cases that the interior wireman is likely to encounter. Any smaller wires should be calculated by the ordinary direct-current rules, for in those cases the inductance is such a small part of the total impedance that it is negligible. It will be noted in the curve for No. 8 wire with 7200 alternations, that the curve and the straight line so closely agree that a point nearest the curve would also be nearest the straight line, and therefore it would make no difference in the wire ultimately chosen, whether direct or alternating-current methods were used. It would be, therefore, legitimate to use direct-current methods where the wire comes out smaller than the sizes shown on the charts.

There is also the case where the wire comes out larger than the sizes shown on the charts and, of course, the latter fail to indicate it. In these cases the inductance forms so large a part of the total impedance of the circuit that it will not pay to try to reduce the latter by reducing the resistance. The drop will have to be endured or neutralized by other methods. Impedance can only be profitably reduced by reducing the resistance within the limits shown on the charts, and many contractors would hesitate to use some of the larger sizes demanded there, but would prefer to submit to the larger drop.

Following are three problems that cover all possible cases.

Problem 1.—Line loss assumed, 5 volts; current to be carried, 5 amperes; distance to be transmitted, 50 ft.; interaxial distance, 10 ins.; frequency, 15,000;

$$\frac{5\ (\text{volts})}{5\ (\text{amperes}) \times 50\ (\text{ft.})} = \frac{1}{50} = .02 = K.$$

It is easy to see at a glance that .02 is a number far too large to be on the chart. It represents a wire of an impedance of 10 ohms per thousand feet and would be about No. 20 wire by direct-current rules. The insurance rules would demand the use of No. 14, for they allow nothing smaller, and that settles the matter as far as interior wiring is concerned.

Problem 2.—Line loss, 2 volts; current to be carried, 200 amperes; distance, 200 ft. interaxial distance, 24 ins.; frequency, 15,000;

$$\frac{2\ (\text{volts})}{200\ (\text{amperes}) \times 200\ (\text{ft.})} = \frac{1}{20{,}000} = .00005$$

With .00005 as an ordinate and 24 as an abcissa a point is indicated which is far from any curve. If the chart was continued to wires of resistance so low that the origin of the curves was nearly to the zero point, thus indicating a wire of nearly zero resistance and, of course, of immense size, yet the curve corresponding would arch high over this point. If such a problem should arise in interior wiring, which is extremely unlikely, the conditions could not be complied with. It would be impossible to construct a line that would produce these results.

Problem 3.—Line loss, 4 volts; current to

be transmitted, 50 amperes; distance to be transmitted, 100 ft.; interaxial distance, 10 ins.; frequency, 15,000;

$$\frac{4\text{ (volts)}}{50\text{ (amperes)} \times 100\text{ (ft.)}} = \frac{4}{5000} = .0008$$

.0008 plotted vertically and 10 plotted horizontally locate a point very near No. 5 wire, the proper size to use. This is a problem that could easily arise in interior wiring.

It would be easy to find cases, as I have done, that come beyond the range of the chart, but the wires thus called for will either be so small that direct-current rules will find them as accurately as alternate-current rules, or so large that no properly laid out installation would demand them. The reader who makes up such problems to test the value of the curves should readily see the reasons why the curves do not respond.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

HOW TO CALCULATE SHUNT COILS FOR SERIES MOTORS.

The embryo street railway repair shop that comes into existence simultaneously with the installation of an electric railway system, however small, soon finds itself in need of machine tools and power to drive them. The tools are duly bought, but the manager hesitates about buying a motor, because he usually has on hand a railway motor or two that he thinks he can utilize.

If one of these motors is put in service it will be found to operate at a terrific speed when no load is imposed upon it, and when it is required to do any work, it slows down, perhaps prohibitively. The speed will be found to be so erratic, that unless hand regulation of the closest character be employed, the power will be worthless.

A railway motor can be easily rewound as a shunt motor, the speed of which will be practically constant, and it is the object of this article to show how to select the wire, and how much of it to use. Only the field coils need to be changed. The rest of the motor is all right as it is.

The first thing to do is to determine the speed at which it is best to run the motor. This selection will be largely influenced by the preliminary experiments that it is necessary to try. Disconnect the armature from the fields and connect the field coils all in series, if they are not already so connected. Construct a water rheostat, and placing it in series with the field, excite the latter from a convenient source of supply, which source will in nine cases out of ten be the trolley system which we will assume is the power that will ultimately drive the motor. The voltage of this source is, we will say, 500 volts. Pass sufficient current through the magnets to excite the latter to their normal strength at full load. If these coils were originally connected in series, this current will be the working current of the motor. If there are two groups in multiple, this current will be half the full load motor current. The first case is the more probable.

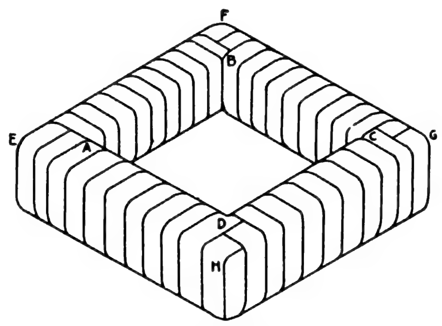
Having brought the field up to its proper excitation, gradually apply the voltage to the armature and when it gets up speed connect it directly across the 500-volt mains. The resulting speed is that at which the motor will run best, but a slight variation can be obtained by weakening or strengthening the field, and would be allowable. Bear in mind that this speed is the speed the motor will make when running light. When loaded, the speed will be a few per cent. lower, and if the speed is important, this should be allowed for.

Having measured and adjusted the speed satisfactorily, carefully measure and record the exciting current and the experimenting is complete.

The next thing to do is to ascertain in some way the exact number of turns to a field coil. This is no secret in a railway repair shop, and it is probable that it may be ascertained without unwinding the coils. In all probability the makers of the motor would supply the information, as they have now become reconciled to the inevitable fact that a street railway corporation will make its own repairs on its equipments.

Multiply the total number of turns in the field coils by the amperes in the field circuit that caused the motor to operate at the proper speed. The result will be the ampere-turns necessary to excite the field. It now remains to design a coil that will operate at the full 500 volts, and will produce the same number of ampere-turns.

It is necessary that the average length of a turn be determined, and to do this it is necessary to make some measurements on the field coil that is to be removed. Fig. 1 shows what dimensions are to be taken: First, the length, $ABCD$, measured on the



FIELD COIL.

inside of the coil; second, the length, $EFGH$, measured on the outside of the coil. These two dimensions are to be added together and divided by two, and the result will be the length of an average turn. This quantity should be reduced to feet and fractions thereof.

We will now call the voltage at which the coil is to operate, E; the mean length of a turn, L; the necessary ampere-turns, A; the resistance per foot of the proper wire to use for the new coil, R.

It is obvious that it is desirable to find R, for with that knowledge we can turn to a wire table and select the proper size Brown & Sharpe gauge at once. For this we may use the formula, $R = \dfrac{E}{LA}$.

We have found all the terms on the left side of the equation, and thus the calculation of R is easy.

It is always well to illustrate the application of a formula by an actual example. Suppose that it is required to construct shunt coils for a 25-HP street railway motor.

We separately excite the field and find that 30 amperes produce a suitable speed, and that with that current the field coils do not overheat. It is found that in all there are four field coils, and that each of these coils has 150 turns, making 600 turns in all. There are then necessary to excite the field, 30×600, or 18,000 ampere-turns. This is the quantity, A. By the measurement and calculation previously indicated, we find the mean length of a field turn to be 40 ins. or 3.333 ft. This is the quantity, L. The voltage at which the coil is to operate we know, in the first place, to be 500. This is the quantity, E.

We may now apply the formula

$$R = \frac{500\text{ (volts)}}{3.333\text{ (ft.)} \times 18{,}000\text{ (ampere-turns)}} = \frac{5}{600} = .008333 \text{ ohm per foot.}$$

Consulting a wire table, we find that No. 19 B & S wire has a resistance of .008477 ohm per foot and is the nearest size. This wire having a slightly greater resistance, would give a little weaker field, and a little higher speed than was prescribed. A special wire could be drawn that would have exactly the proper resistance, but this No. 19 is so nearly what is wanted, that it would probably be used.

The next question is how much wire to use, and it may be briefly answered. The new field coil should be of the same size as the one taken off. If it is larger the field coil will run cooler and take less current, and if it is smaller the field coil will run hotter and take more current than if the shunt coil was of the same size as that of the series coil that it replaces. The magnetizing effect will be practically the same in either case, and within certain limits the number of turns put on does not affect the magnetizing power of the coil. It is highly important, however, that each of the coils has exactly the same number of turns. It may also be remarked that as small wire packs into a closer winding than large wire, the finished shunt coil is apt to weigh a little more than the series coil that it replaces. As long as the dimensions of the original coil are not exceeded, the more wire that the coil contains the cooler it will run. When the dimensions of the original coil are departed from, the magnetizing power begins to be affected, for this varies the mean length of a turn. Fortunately, however, a considerable departure from the prescribed dimensions is necessary before the effect becomes even noticeable.

THE SLIDE VALVE DIAGRAM.

In a preceding article a practical method of laying down a slide valve diagram for a given engine was explained, and in this such diagrams will be used to illustrate several interesting points of slide valve operation.

It sometimes happens that the steam valve over-runs the port, and in the cases of fast-running automatic engines this is almost always the case at normal power, for reasons that will be given later on. This, however, does not introduce any complication in the valve diagram, as will be seen by reference to Fig. 1.

In the illustration, BOL is the angle between the crank and eccentric, LOM the throw or travel of the valve, Or the steam,

and $O\,v$, the exhaust lap. If when the valve is at one end of the stroke, its edge is flush with the edge of the port, then, $r\,L$, would, to the scale of the drawing, be the width of the port; if, on the contrary, the valve over-runs by an amount, $L\,s$, then by drawing the arc, $s_1s_2s_3$, the width of port would be represented by s_2r. Laying off $v\,w_2$, we find w_2M, to be the corresponding over-run of the exhaust side of the valve.

We will now follow the events of the stroke, bearing in mind that in the valve diagram we must imagine the crank to go from A toward B, opposite to its natural direction, which, on account of the situation of the eccentric, would be from B toward A. It will be seen that admission begins before the piston reaches A or the end of its stroke, and that when on the center the valve has a lead, or is open an amount, fg; while the crank goes from A to k, the port opening increases; owing to over-running there is a full admission port opening, s_2r, from k to l; at l the valve begins to close the steam port and the steam is finally cut off as shown. The steam begins to exhaust, it will be seen, considerably before the end of stroke, the valve, in fact, being almost full open at end

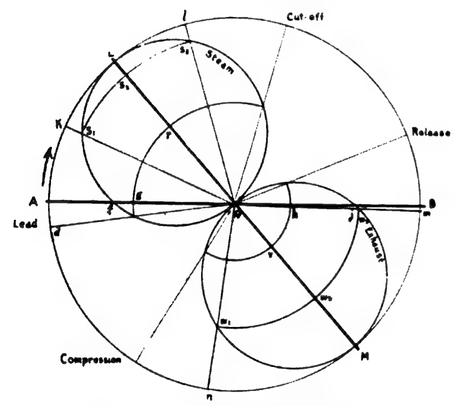


FIG. 1.—SHOWING OVER-RUN.

of stroke as the diagram is drawn, the point of full opening being m; from m to n, the exhaust is wide open, at the latter point commencing to close; expansion then takes place while the crank is going through the angle between the points marked "compression" and "lead."

What would be effect of moving the eccentric of an engine ahead? Suppose the eccentric of the engine, whose valve diagram is given in Fig. 2, is moved ahead from L to L'. Drawing the lines (shown dotted) corresponding to lead, cut-off, etc., of the new setting, we find: 1°. That the lead is earlier, being at d' instead of d, thus causing the valve to be about three-quarters open at beginning of stroke. 2°. Steam is cut-off at a' or earlier in the stroke, causing greater expansion. 3°. The release is much earlier, or at b' instead of b. 4°. Compression begins earlier, or at c' instead of c.

We thus see that by advancing the eccentric all events are made earlier, and that while the expansion is increased, excessive leads result and compression back pressure is increased.

Now let us see what follows if the throw of the eccentric is decreased. In Fig. 3, suppose the half throw of the eccentric is decreased from L to L', the angular advance remaining the same. Drawing as before, in dotted lines, new valve circles, and lines corresponding ot the lead and cut-off under the new conditions, we find: 1°. That the lead is later, the admission not beginning until d' or after the crank has passed its dead center. 2°. The cut-off is

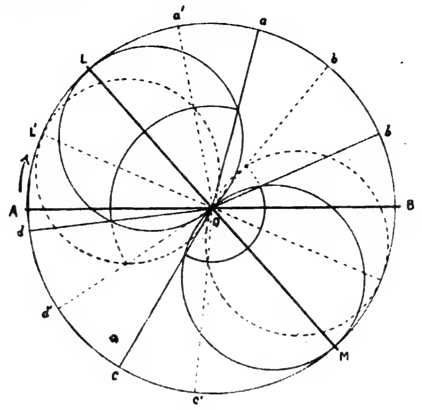


FIG. 2.—SHOWING EFFECT OF ADVANCING ECCENTRIC.

earlier or at a'. 3°. The release is later, or at b' 4°. The exhaust is closed earlier, or at c'.

We thus see that while by decreasing the stroke expansion is increased, compression is also increased and both steam and exhaust lead are made late. Since, however, in this case the leads are made later, and in the case of increased angular advance they are made earlier, it is obvious that by making the two changes simultaneously, the leads may be retained approximately constant while the expansion is varied, though compression will still vary in the same direction as the latter.

It is, in fact, upon the latter principle that all automatic fast-running slide-valve engines work. In such engines the eccentric is generally secured to a swinging arm connected with the governor, and by the latter the position of this arm is so varied that the center of the eccentric swings toward or away from the center of the shaft; the arm is also so pivoted that for any position it assumes, the angle between the crank and a line joining the shaft and eccentric centers, is changed simultaneous with the change in throw caused by the center of the eccentric

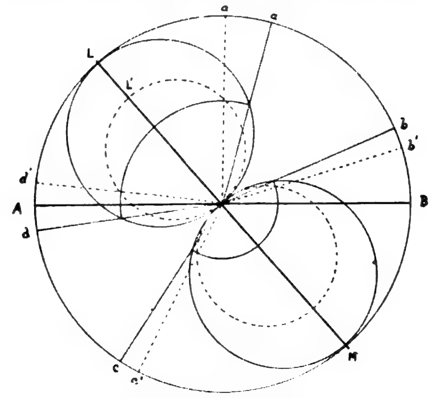


FIG. 3.—SHOWING EFFECT OF SHORTENING THROW.

swinging toward or away from the center of the shaft.

Fig. 4 shows a swinging eccentric valve diagram. Here the angle, $B\,O\,L$, is the normal crank and eccentric angle, or rather that corresponding to normal load. When the load becomes lighter, the governor actuates the swinging eccentric arm, and approaches the shaft and eccentric centers, thereby decreasing the throw, and at the same time increasing the angle between the crank and the line passing these centers.

By making, when such an engine is at rest, the governor balls take different positions, the throws and angles corresponding to different cut-offs may be obtained and plotted on a valve diagram. For example, having first constructed the valve diagram (shown in full lines) for one position, the governor weights may be blocked out and the engine then turned until the valve just closes at cut-off; then measure the angle the crank has advanced, lay it off as $A\,o\,a'$, and through the point where this line cuts the lap circle draw the dotted circle, which will be the new steam circle, corresponding to which we draw an exhaust circle. If a number of circles are thus obtained, it will be found that the point, r, of their diameter which passes through O, will all lay on a curve like $L\,h\,c$, which is called the locus of the eccentric centers.

Let us compare the events corresponding to the throw, $O\,r$, and the crank and eccentric angle, $B\,O\,L'$, with the normal throw,

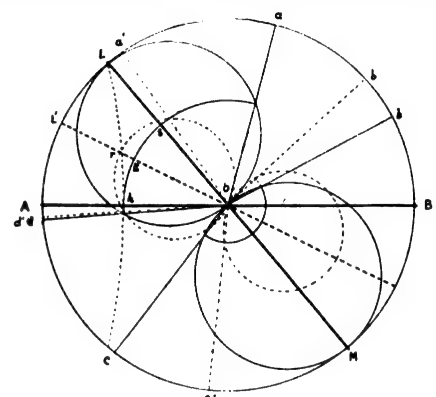


FIG. 4.—DIAGRAM OF AUTOMATIC ENGINE-VALVE GEAR.

$O\,L$, and the angle, $B\,O\,L$. We see that the cut-off has been advanced from one-half stroke to less than quarter stroke while the steam leads, dd', remain almost the same, the exhaust leads being somewhat earlier; the compression is also earlier, or at c' instead of c.

It will be noted, however, that while at normal load the full steam opening was Ls, at the new load this opening is only rs. To remedy this, in practice the valves of such engines are given a considerable over-run, the throw being increased for this purpose. By referring to Fig. 1, it will be seen that if the over-run circular arc, $s_1s_2s_3$, were drawn in Fig. 4 near to r, the steam opening for the two loads, would not practically differ greatly, though the throw would have to be almost doubled to enable this to be done.

While automatic engines with swinging eccentrics may be made to work smoothly for cut-offs varying from one-tenth to eight-tenths stroke and even wider limits, no valve motion can be designed for an engine with a single fixed eccentric that will give satisfactory results for a cut-off greater than about one-half. By adding some form of a link, however, such as the Stephenson, the cut-off can be greatly increased, as in the case of locomotive engines; but no link motion is as satisfactory as a movable eccentric.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

While the great discovery of Volta gave an enormous impetus to electrical science, the practical fruits were meagre during the succeeding 20 years, the extensions of knowledge, aside from electro-chemistry, being mostly confined to obvious developments. The great attention given to electro-chemistry, during this period, however, resulted in establishing that science on a firm basis, and in definitely withdrawing chemical science in general from its former alliance with alchemy.

It was with the birth of electro-magnetism in 1820 that another and greater period was begun—a period in which the seed was planted that, after a dormant stage of half a century, developed into the wonderful electrical growth of to-day. And the beginning of this was an apparently accidental observation by a Danish professor during a class lecture, of the deflection of a magnetic needle approached to a conductor carrying a current.

Hans Christian Oersted (1777-1851) like his great contemporaries, Davy and Faraday, had no advantages of birth, but like these rapidly rose to a distinguished position in his country through the development of brilliant qualities. At an early age he became a member of the scientific faculty at Copenhagen, and under the auspices of his government, from 1801 to 1804 made, like Volta, a scientific tour of the learned capitals of Europe, during which he met the savants of his day. Upon his return he became a full professor at the University of Copenhagen, devoting himself to physics and chemistry. In the latter branch he did much work, among other things founding the theory of silicates. The unity of nature was one of his beliefs and he maintained the universality of chemical, magnetic and electrical forces, though apparently in a metaphysical rather than in a scientific manner. At any rate, we have been unable to find any references to any attempted practical proofs of his theories.

The great discovery which has rendered his name famous was made July 21, 1820, during a lecture to his students. The discovery consisted in the observation of the deflection of a magnetic needle when it was approached to a conductor carrying a current, and was announced as a deduction from theoretical ideas. In fact, Oersted claimed that he was guided to the discovery by theoretical views he had published 20 years before.

However, this may be, great honors came to the fortunate observer. The French Academy bestowed a prize of 3000 francs on him—in its haste to do the Danish savant honor—diverting this prize from a totally different object for which it had been founded. Later, his countrymen secured to him as a residence for life the Château Fasanhof near Copenhagen, and the ceremony of presentation and escorting him to his new residence were of a royal character. Beyond collaborating with Fourier in the construction of the thermo-pile, and some studies in diamagnetism, Oersted did nothing of note in the remaining years of his life.

The news of Oersted's discovery rapidly spread throughout Europe, and savants everywhere eagerly took up the study of the new phenomenon. Like all great opportunities, it served to bring forth genius, appearing, in this case, in the person of Ampère. As this great savant is reserved for the subject of a future article, it will here be merely mentioned that in the short space of five months after he learned of Oersted's discovery, he laid the entire base of electromagnetism, the intellectual achievement involved having been pronounced one of the finest in the history of the mind. Besides Ampère and Faraday another name that looms up in the period under consideration is that of Arago.

Doménique François Arago (1786-1853), was educated at the Ecole Polytechnique, and after graduation became attached to the Paris Observatory. He was one of the four members of the French commission appointed to measure an arc of the terrestrial meridian in order to determine the length of the metre, and while thus engaged had some rather remarkable personal experiences. Arrested by the Spanish as a spy, he managed to escape to Algiers; while returning in a ship to France the vessel was captured by Barbary pirates and he was taken back to Africa; when released some time after, the ship upon which he took passage to France was wrecked on the coast of Africa. The next attempt was through a gauntlet of British war ships, but was successful.

FRANÇOIS ARAGO.

Arago, soon after the announcement of Oersted's discovery, showed (Sept. 20, 1820), that a conductor carrying a current acted upon iron filings in a manner similar to a magnet, and illustrated this effect by the now familiar magnetic phantom. About the same time he demonstrated that a magnet can be formed by placing an iron or steel bar within a solenoid, and also that a rod of steel may be given a number of poles by placing it within a solenoid so wound as to cause the current in successive portions to have opposite directions, the name of *consequent* being applied by him to other than the terminal poles thus formed. In the same year he predicted that the voltaic arc could be deflected by a magnet, which prediction was experimentally substantiated by Davy the following year (1821). Upon the announcement of the magnetizing effect of the solenoid, it was pointed out that Franklin and others had noted that the static charge could produce magnetism in small pieces of steel, but Argo replied that there was a vast difference between mere observations of an effect on their part without knowledge of the manner in which it was produced, and his discovery how to actually manufacture magnets of every kind at will. It might have been answered that the latter discovery, in view of Ampère's previous discovery of the magnetic properties of the solenoid, was in itself no particular achievement.

Arago's greatest discovery, though its significance at the time was not realized, was that of the effect of magnetism on non-magnetic bodies—the forerunner of Faraday's discovery of electromagnetic induction. In 1824 he noted that if a non-magnetic body were oscillated in close proximity to a magnet, a disturbing influence on the former became apparent. The following year he constructed what is known as "Arago's disk," consisting of a horizontal non-magnetic disk capable of being given a rapid rate of rotation and having suspended above its center a magnetic needle; upon revolving the disk, the needle also takes up a motion of rotation, due to the action on it of the induced current set up inthe disk by the magnetism of the needle.

Arago also made a number of contributions to terrestrial magnetism, but his activities were by no means confined to the electrical field. The resumés which frequently appeared from his pen on the current state of different branches of science were masterpieces of lucid writing, and his many biographical notices on men of science will always hold a high place in scientific personal literature. He was a most indefatigable worker to the day of his death. When partly blind during the last three years of his life, it is related that he daily dictated almost ten hours, besides delivering one or more lectures.

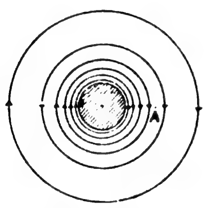
An episode in the scientific life of Arago recalls the fact that the electrical "fake" is not a modern appearance. Much interest had been excited in Paris about 1846 by the singular manifestations of a so-called electric girl. To a young girl about 13 years of age was ascribed the property of deflecting a magnetic needle and of electrifying any object placed in contact with her person or clothing, while she was said to be capable, through electrical power, of performing wonderful feats of strength. Arago was one of a commission of scientific men named to report on the human phenomenon, and upon investigation found that it was a pure and simple case of imposture. Not only was the subject devoid of the properties ascribed, but it was found that her apparent feats of strength were merely the result of skillful tricks of the hands and feet.

LESSONS IN PRACTICAL ELECTRICITY

INDUCTIVE DROP ON ALTERNATING-CURRENT LINES.

Owing to the omission of a cut from the article on this subject in the February number, and to several confusing typographical and numerical errors in the text, some difficulty was doubtless encountered in its reading. As the inductance of alternating-current lines is of so much importance, in this article it will be taken up again, and while there will necessarily be considerable repetition of what appeared in the previous article, the treatment will not be identical.

Very shortly after Oersted's discovery of the influence on a magnet of a conductor carrying current, Arago showed that iron filings would arrange themselves circularly about such conductors. About the same time Biot and Savart showed that the measure of the force exercised at any point by a current in an indefinitely long conductor, is expressed by the formula $2\,c \div r$, where c is the strength of current, and r the distance of the point from the conductor. This becomes $\frac{.08C}{r} = \frac{C}{25r}$ if the current is expressed in amperes and r in inches. Later, Faraday put forth the conception of lines of force according to which when unity force is exerted at a given point, the density of



LINES OF FORCE ABOUT CONDUCTOR CARRYING CURRENT.

lines of force at that point is unity, or one line of force per square centimeter.

We can thus conceive that in the case of any looped circuit, whether a coil or a transmission or distributing line, the area of the loop is filled with lines of force set up by the current flowing in the conductor. The number of these lines depends upon the current passing in the conductor, and also, as we shall see, upon the distance the conductors are apart.

The circular lines of force about the conductor are not confined to its immediate proximity, but exist at indefinite distances away. By referring to the accompanying figure, it will be seen, however, that as the distance from the conductor increases, the density of lines of force becomes smaller. Therefore, if the two conductors of the loop are close together, many of the lines of force of one conductor will pass beyond the other conductor, and not be included in the area of the loop. By reference to the accompanying figure, it will also be seen that the density of the lines of force decreases quite rapidly as the distance from the conductor increases, so it is obvious that beyond a certain point a further increase of the distance apart of the two conductors will not appreciably add to the number of lines in the loop.

Now, if the current passing through the conductor is an alternating one, in each alternation all the lines of force due to the value of the maximum current must pass out of the loop, if the current is decreasing from maximum to zero; or pass into the loop, if it is increasing from zero to maximum. In doing so, we may consider that these lines cut the conductor in the same manner that an armature wire is cut by the lines of force through which it passes in the field of a dynamo. The E. M. F. thus produced is called an inductive E. M. F. or the E. M. F. due to inductance, and since it acts, as is the case with all induced currents, opposite to the E. M. F. which produces it, the result is to decrease the line E. M. F., the amount of such decrease being called the inductive drop.

In addition to the lines of force within the area of loop, there are also lines within the conductor itself. We can conceive of the current in a conductor to consist of an indefinite number of filamentary currents, each of which will set up its lines of force, and some of which will, of course, be in the body of the wire. It follows therefore that even if two conductors of a loop are placed infinitesimally close to each other, there will still be lines of force to set up an inductive E. M. F. if the current flowing is varied in value; consequently, while the inductive E. M. F. may be much reduced by putting the wire closely together, it cannot in this manner be nullified, even if the wires should be so close together as to be on the point of touching.

This case must not be confused with the inductive effect on neighboring circuits of wires carrying varying currents, for in this case, if the two conductors are very close together, and the neighboring circuit at a considerable distance away in comparison with the size of the wires, the circular lines of force of the two conductors may be considered as having a common axis, and therefore the lines of one conductor will neutralize, at a neighboring point, those of the other, since they have opposite directions.

In the previous article it was shown how the entire number of lines within a loop can be calculated for a given current, length of loop and distance apart of conductors. In practical work, however, the only cases met are in connection with alternating current working, and it was shown that the inductive E. M. F. per thousand feet of wire of a loop carrying alternating currents is obtained by multiplying together the current in amperes, the frequency in periods per second and the fraction, $\frac{.9575 + 8.82k}{10{,}000}$ in which the value of k depends upon the distance apart and size of the conductors. In a table in the February issue the value of k is given for a number of values of $\frac{D}{d}$, D being the distance apart of the two conductors of the loop and d their diameter. As a formula the above is expressed

$$E' = \frac{Cn\,(.9575 + 8.82\,k)}{10{,}000},$$

E' being the inductive drop or E. M. F., C the current in amperes, n the frequency in periods per second, and k as above explained.

As an illustration, the formula will be applied to four circuits, each 10,000 ft. long, or each containing 20,000 ft. of wire, one circuit being of No. 0 wire, another of No. 3 wire, the third of No. 6 wire and the fourth of No. 9 wire. From a wire table it will be found that the resistances of the given lengths of these wires will approximately be 2.2, 4.4, 8.8 and 17.6 ohms, respectively. Further, suppose the voltage of the circuit is 2200 volts, and that an ohmic loss of 10 per cent. is permissible, or 220 volts. From Ohm's law, $C = E \div R$, we find that the currents to produce these ohmic drops will be 100, 50, 25 and 12.5 amperes, respectively.

Suppose that the conductors are in each case 15 ins. apart. As the diameter of No. 0 wire is .325 ins. we have for the valve of $D \div d$, $15 \div .325 = 46$, and from the table referred to we find that this corresponds to a value of k of 1.95. Similarly, we find the value of k for No. 3 wire to be 2.1, 2.24 for No. 6 wire and 2.41 for No. 9 wire. It may here be remarked that if the value of $D \div d$ in a given case does not accord exactly with any one of the values given in the table, it will be sufficiently accurate to interpolate by proportion.

Finally, assuming 125 periods for the frequency, we have all the numerical values to substitute in the formula, or the values of C, k, and n. Making the substitution, and multiplying by 20 since there are 20,000 ft. of wire and the formula is for but 1000 ft., we find the inductive drop to be 453 volts for the No. 0 wire circuit; 243 volts for the No. 3 wire circuit; 129 volts for the No. 6 wire circuit, and 69 volts for the No. 9 circuit. That is, while the ohmic drop remains the same for each wire or 220 volts, the inductive drops range from 69 volts for the smallest wire to 453 volts for the largest.

In practice, however, what is required is the combined effect of the ohmic and inductive drops, and this is obtained not by adding the numbers representing them together, but by adding their squares and extracting the square root of the sum. In the case, therefore, of the No. 0 wire the effective drop will be $\sqrt{220^2 + 453^2} = 504$ volts. Similarly, we find the effective drop to be 327, 255 and 230 volts, respectively, for the circuits of No. 3, No. 6 and No. 9 wire. That is, while the ohmic drop in each case is 10 per cent., the total drop when alternating currents are used, becomes 23, 15, 11.7 and 10.5 per cent. for the No. 0, 3, 6 and circuits respectively. It will thus be seen that even for the extreme case of a frequency of 125, the effect of inductive drop on a circuit of No. 9 wire is negligible, and the increase for a No. 6 wire is small. A rule, therefore, sufficiently close for practical purposes is that sizes of wire above No. 6 or 8 can be calculated for alternating currents by the same formulas used for continuous currents.

Suppose that it were possible to reduce the ohmic resistance of the No. 0 wire to zero, what would then be the drop in the circuit above considered? The effective drop would then be the inductive drop alone or 453 volts, or the drop of the line would only be decreased from 23 to 20.7 per cent. By substituting a No. 0000 wire for the No. 0 wire, the total drop would only be decreased to 468 volts, or from 23 to 21.3 per cent. If,

on the other hand, the No. 0 circuit were divided into two No. 3 circuits (the amount of copper thus remaining the same since the area of a No. 0 wire is double that of a No. 3 wire) the drop would be reduced to 15 per cent.; and if 4 No. 6 circuits were used, the same weight of copper would also be employed, but the drop would be reduced to 11.7 per cent. In general, the only practicable way to avoid the bad effects of inductive drops on alternating circuits is to divide the circuits.

The large inductive drop that results when large wires are used does not result from the large size of the wire, but from the large current flowing. This is evident from the fact that the drop is caused by lines of force whipping in and out of the loop, and the larger the current the larger the number of such lines. As far as the size of the wire affects the result, the inductive drop per ampere actually becomes less as the size of the wire increases.

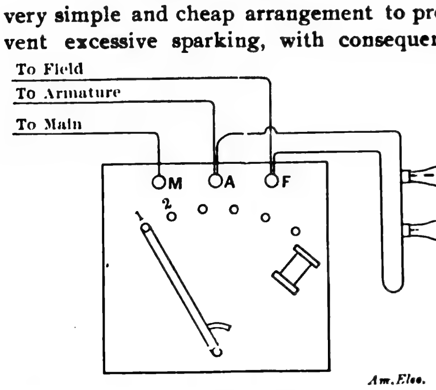
We have considered above the inductive drop rather than inductance. If the inductive drop in a conductor is divided by the current flowing in the conductor, the result is called the inductance of that conductor. Since by dividing the ohmic drop by the current we obtain the resistance of a conductor, it will be seen that inductance is a property similar to resistance. We can, however, form some sort of a tangible idea of the nature of electrical resistance through analogy with the mechanical resistances with which we are familiar, as in both cases the result is heat. In the case of inductance, however, there is no heat and no energy loss, and it is therefore difficult to form a tangible conception of it. Besides, in most or all practical cases, what is desired to be known is the inductive drop, and therefore it would appear to be more reasonable to calculate directly this drop, as has here been done, than in our calculations introduce the intermediate factor of inductance.

Letters from Practical Men

A Motor Rheostat Kink.

To the Editor of the American Electrician:

The accompanying sketch represents a very simple and cheap arrangement to prevent excessive sparking, with consequent



burning, at the final segments of motor automatic starting boxes. Ordinarily there will be a flash when the lever passes from 2 to 1, on account of the magnetic discharge of the rheostat; by placing two incandescent lamps in circuit, as shown, this flash will be avoided. I have under my charge both 110-volt and 220-volt motors, which are thus equipped; on the rheostat of the former is one 110-volt lamp and on the latter two 110-volt lamps, in series.

GEO. W. HARROLD.

Philadelphia, Pa.

Alternating-Current Working.

To the Editor of the American Electrician:

Replying to the query of "Graduate" in your February issue, within the limits of variation of commercial machine, the matter of the shape of wave is rather unessential. Since, however, machines giving a distorted wave shape have, as a rule, a higher armature reaction, the running in multiple of two machines widely differing in this respect may be objectionable—not directly on account of the wave shape itself, but because of the internal reactions of the machines. If, for instance, an iron-clad machine is running in multiple with a smooth-core machine, and both are separately excited, the iron-clad machine, since it usually has higher self-induction and armature reaction than the latter (which gives a curve of sine-form approximately), the smooth-core machine will take more of its share of the total load. The reason for this is that the effect on the smooth-core machine having low armature reaction, of a certain amount of current in the armature will be less demagnetizing than in the core of the iron-clad machine; consequently, the voltage of the smooth-core machine will be higher, and therefore, this machine will take more load. However, if the machines have compound fields, and the fields are properly adjusted, it is possible to run them in multiple commercially without any particular difficulty.

The question of equalizer and alternator is of considerable importance. It is always necessary to have such a device on machines with large compounding—that is, of high armature reaction— and particularly so if they run in multiple with machines of different armature reactions. Machines with small compounding may be run successfully without an equalizer. The equalizer connection is always made by connecting together the two positive and two negative brushes, respectively, of the rectifying commutator.

Regarding the resultant wave in a line supplied with currents from two alternators of different wave shape, it is a very simple thing to construct this curve, directions for which will be found in almost any electrical text-book. As a rule, however, the operation is rather laborious, since the distorted wave has to be analyzed for the fundamental and higher harmonics and then plotted or expressed algebraically and the components combined.

ENGINEER.

New York.

Some Problems in Alternating Current Working.

To the Editor of American Electrician:

The following may throw some light on the questions propounded by "Graduate" in the February number.

1. Alternators giving different wave forms have been successfully operated in parallel both experimentally and in actual service.* Other things being equal, the exchange of current between two machines will be greater when the pressure wave of one is peaked and that of the other flat topped, than were both alike; and this is somewhat detrimental, because the so-called synchronizing current uses up the capacity of the machines.

2. Fig. 1 shows a graphical method of

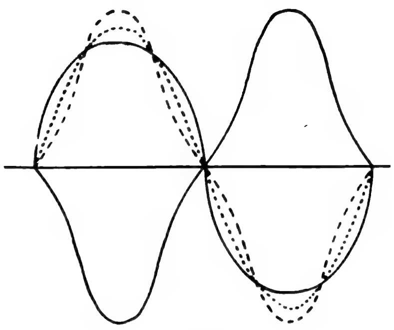


FIG. 1.

plotting the resultant pressure wave of two alternators feeding the same bus bars. The two heavy lines represent the curves of pressure of two machines, in proper phase relation for parallel operation, i.e., their waves are 180 degs. apart. To get the resultant, one curve is reversed, as indicated by the dash line, and the resultant wave will then be a curve whose ordinate at any instant is a mean between the corresponding ordinates of the reversed curve and of the curve of the other machine. This resultant is represented by the dotted line. If a third alternator, having a still different wave were now thrown on, its pressure wave could be combined with the resultant just found, and by the same method, and the final curve would be the resultant of the three machines. Dr. Fleming has actually taken the curves of a Mordey alternator and a Thomson-Houston alternator operating separately and in parallel. The curves of the two machines are quite different in form.†

3. If two machines of equal capacity and voltage, one having a toothed armature and the other a smooth core armature, were operated in parallel, the division of load would be equal providing the excitation of each machine were properly adjusted. The larger self-induction of the toothed armature would tend to choke back the excess of synchronizing current due to the difference in wave forms; but this same self-induction would, on the other hand, cause the machines to hunt, and this tends toward an increased exchange of current.

4. In operating alternators in multiple it is necessary to use equalizer connections if the machines are compounded. The accompanying diagram (Fig. 2) shows the method of connecting two single-phase composite-wound alternators for parallel working. *A A* are the armatures, *f f* the series fields *B B* the bus bars, and *S* the synchronizing lamp connected to its transformer. It will be noted that the same lamp can be used no

*C. E. L. Brown.—*Journal* Institute Electrical Engineers, Vol. 22, p. 600.

C. P. Steinmetz.—*Electrical World*, Vol. 23, p. 285.

† Dr. Fleming.—*London Electrician*, Vol. 34, p. 460, 507.

matter which machine is started first. The equalizer bars, $E\,E$, are two in number and connect the brushes of like polarity of the two rectifiers through a double-pole switch. By having two equalizer bars all differences

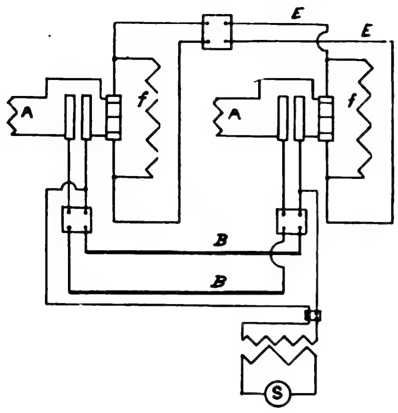


FIG. 2.

in the machines are compensated for while the current is a direct one, and the result is very satisfactory working.

The whole subject of parallel working is thoroughly treated in a new work entitled "Alternating Currents and Alternating Current Machinery," by D. C. Jackson and J. P. Jackson. Macmillian Company. Chapter VII., p. 313.

Madison, Wis. BUDD FRANKENFIELD.

ELECTRICAL CATECHISM

102. Does the resistance of the primary circuit change, so as to let more current pass when the secondary gives more current?

No. The resistance of the primary circuit remains constant. Ohm's law, in its simple form, does not always hold true for alternating currents. For instance, the primary circuit of the transformer just mentioned has a resistance of not quite three ohms. One might expect that when such a resistance was connected across a 1000-volt circuit, more than 300 amperes would pass, unless something happened to open the circuit. As a matter of fact, less than one-fourth of one ampere flows through the primary of this transformer, if the secondary circuit is open so that it delivers no current.

103. How does the current taken by the primary increase when the secondary current increases?

This matter is somewhat complicated, but may be explained in an elementary, although incomplete way as follows: Since the induced electromotive forces in the coils are in the opposite direction to the E. M. F., sending current through the primary coil, it follows that the current in the secondary circuit is also in the opposite direction to that in the primary. The result is that the secondary current tends to magnetize the iron core in a direction opposite that of the primary current. This opposing magnetizing force would weaken the resultant magnetization and so reduce the electro-motive forces in the two coils. But the reduction in the counter electromotive force in the primary coil allows more current to pass through the primary coil and so to bring up the voltages in both coils to nearly the same values they had before. In practice it is found that this complex action goes on regularly, so that the current through the primary increases in almost exact proportion to that in the secondary. The more complete theory of this reaction is complicated by the fact that the electromotive forces and currents in the two circuits reach their corresponding maximum values at different times, the primary current always being more or less behind the primary electromotive force.

104. Do not some transformers give a constant current from the secondary?

Yes. A few transformers have been made for use on series circuits carrying alternating currents of constant strength. One of the large companies formerly had an alternating system for operating arc lamps in series. When it was desired to have arc lamps in buildings or other locations where persons were liable to touch the lamps, these were usually fed from the secondary circuits of constant-current transformers. This system was abandoned, and the common practice, when arc lamps are used on alternating-current circuits, now is to operate them from transformers connected to the constant-potential mains used for incandescent lamps.

105. Can transformers be made to give secondary current of constant strength when the primary is connected to a constant-potential circuit?

Several companies make transformers that give approximately constant current within modern ranges of voltage when the primary is supplied at constant potential. This is usually accomplished by designing the transformer so that there will be considerable magnetic leakage. As stated before (No. 103), the current in the secondary coil has a magnetizing effect in the opposite direction to that of the primary current. This counter magneto-motive force makes it more difficult for the magnetic field from the primary to pass through the secondary, and so more of the magnetic lines of force leak across without threading through the secondary coil, as suggested in Fig. 1. Since the electromotive

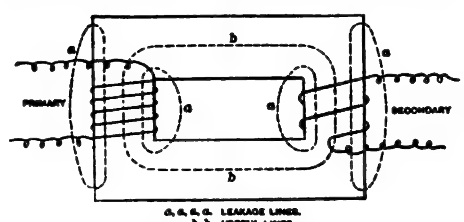


FIG. 1.—DIAGRAM OF TRANSFORMER.

force in the secondary coil is proportional to the number of magnetic lines of force enclosed by it, it follows that the greater the amount of leakage the less will be the secondary electromotive force. It follows further that if the secondary current increases, the leakage will also increase, thereby diminishing the secondary electromotive force and in turn diminishing the secondary current. By suitably designing the magnetic circuit, the leakage field will increase in such proportion to the increase of secondary current that the secondary current will remain nearly constant.

106. What is a rotary transformer?

A rotary transformer is a machine for changing a continuous current into an alternating current or *vice versa*. Such a machine is practically a dynamo or motor having a commutator like that of a continuous-current machine and also two or more collecting rings like those on an alternator The collecting rings are connected to equidistant bars of the commutator, as explained in the AMERICAN ELECTRICIAN, Feb., 1897, page 40. Suppose that collecting rings are electrically connected to two opposite bars of a commutator such as A and B in Fig. 2.

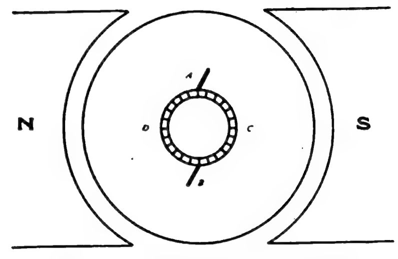


FIG. 2.—BIPOLAR GENERATOR.

When these two bars are directly under the brushes as in the figure, the voltage between the two rings is the total voltage of the machine. When the armature has rotated one-quarter revolution so that the bars to which the collecting rings are connected are in the position, $C\,D$, there is no difference of potential between the two rings, although one-half the total voltage exists between either ring and either brush, A or B. In passing from the maximum position at $A\,B$ to the zero position at $C\,D$, the voltage between the two collecting rings varies more or less closely according to a sine curve as shown in Fig. 3. If the armature is driven

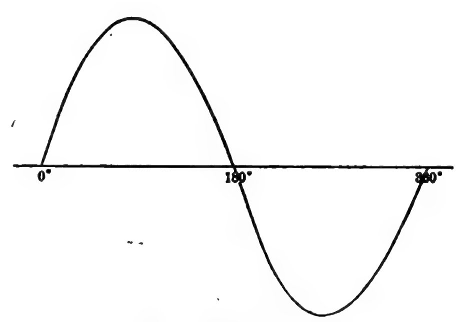


FIG. 3.—SINE CURVE.

as a motor by continuous current supplied through the brushes, A and B, an alternating current may be taken from other brushes making contact with the collecting ring. Evidently the maximum value of the alternating voltage will be equal to the steady voltage between the two brushes, A and D. The mean alternating voltage will be about 71 per cent. of this.

107. Will a rotary transformer also obtain a continuous current from an alternating current?

Yes. If the motor is arranged so as to be driven by alternating current supplied through the collecting rings, then a continuous current can be taken from the brushes, $A\,B$, bearing on the commutator.

108. Are rotary transformers used much?

These are largely used at Niagara Falls and other plants for obtaining continuous current from an alternating plant.

Queries and Answers

Must the resistance of a series-wound motor be equally divided between the field and armature? F. S.

No; for a given machine the resistance of each will be independently settled by considerations of design, efficiency and heating.

1°. Can the core of the armature of the motor described in the February number be made of a solid piece of wrought iron? 2°. What is the width of the field frame? H. S.

1°. No; the eddy current loss would be too great. 2°. The width, which is shown in Fig. 2, is 3 ins.

How can I transform a one-twelfth-HP, series-wound, bipolar motor into a shunt-wound dynamo? W. K. B.

Instructions are given in another column for changing a series-wound into a shunt-wound machine, which apply to both dynamos and motors. A small motor will often not generate when run as a dynamo.

1°. Is there a limit to the length and diameter of the core of an induction coil? 2°. Would it be advisable to wind the secondary with several conductors in parallel instead of in a single length? R. E.

1°. The length of the core of an induction coil fixed by the amount of wire to go on the secondary, and its cross section by the number of lines of force it is to carry. 2°. See the article on this subject on another page.

How large a motor will be required to drive a 20 ft. cedar launch, and how many storage batteries will be required to drive the motor? L. E. R.

The size of the motor will depend on the speed, but one of 2 HP would probably answer. The size of the battery will depend upon how long it is to operate on a single charge. Batteries can be had weighing 100 lbs. per horse-power hour, so that if the boat is to run five hours without recharging the weight will be 1000 lbs., and the battery will consist of, say, 25 150-ampere-hour cells.

I have a 5-KW, 110-volt dynamo and would like to build a small storage battery to be charged from it and which will run two 110-volt lamps. Please give instructions for making the cells. N. W. K.

As at least 45 cells will be required for charging from a 110-volt circuit, such a battery would be expensive. It would be better to employ battery or low-voltage lamps and only use a half dozen small cells, which may be charged by placing them in series in the dynamo shunt circuit for charging; this may be done without interfering with the working of the dynamo if some of the rheostat resistance is cut-out. For the cells, see answer to S. T. B., in February issue.

1°. I have a small induction coil, and experience trouble with the contact-breaker; at times the platinum screw tip seems to stick to the spring, which is armed with platinum, after running a few seconds; what is cause and remedy? 2°. What is meant by a 5-in. induction coil? B. F. K.

1°. If you have a condenser on the coil, by reducing its capacity the sticking will be notably less. If storage cells are being used, the trouble may lie in the stoppage of the vibrator for a moment and the subsequent welding of the contacts, due to the heavy current flowing. To correct this, adjust the vibrator so that the danger of momentary stoppage will be minimized. 2°. A 5-in. induction coil is usually understood to be one that can strike five inches between terminals.

1°. What is the advantage of single over double reduction or gearless motors? 2°. In insulation resistance, what is meant by "one megohm per mile?" W. P. C.

1°. Among the advantages of single over double reduction motors are less wear and tear, less noise and simpler mechanism. The gearless motor is heavier, more expensive, less adaptable for grades and less flexible in operation. 2°. When the insulation resistance of one mile length of a conductor is 1,000,000 ohms, it is said to have an insulation resistance of one megohm per mile; the insulation resistance of one foot of the same conductor would be 5280 megohms, and of ten miles one-tenth megohm, as the leakage surface is decreased or increased in those proportions.

In an article on storage batteries in the November number, it is stated that the voltage of the charging current is 2.5 amperes. The battery consists of 58 cells and 10 counter E. M. F. cells, necessitating 170 volts, calling for a dynamo of rather an odd voltage. Is this correct, and if so, how can the voltage when charging be adjusted for the 110 volt lamps in circuit? C. C. S.

The statement is correct. The lighting circuit when charging has only 44 cells on it, the others being switched out, but kept in the charging circuit. A certain manufacturer of dynamos had the same idea about the voltage when, several years ago, a charging dynamo was ordered from him. Learning that the number of cells was to be 55 (the circuit voltage was 100) he supplied a 110-volt dynamo--and then exchanged it for one giving 140 volts with an empty rheostat.

What changes in the construction of the Wimshurst machine, described in the November issue of the American Electrician, will be necessary in order to use two disks? W. S.

In order to make a machine of more than two disks, it will be well to mount two of the disks on either end of one hub and the two other disks each on its own hub. The center hub may be revolved in one direction and the two outer hubs in the opposite one, thus making three driving wheels on the lower shaft. The middle belt had better be the crossed one and the two outer ones open. A special method for holding the short-circuiters will have to be devised. It will be better to make the sectors about one-half the width, and two-thirds the length of, those described in the November issue, altering the combs to suit.

1°. I have trouble with fuses burning out on the main circuit of a 65-ampere, 110-volt dynamo. The fuse box is just above the main switch, and though fused with wire marked 100 amperes, it heats badly and sometimes blows. Kindly explain the cause. 2°. Can a 110-volt dynamo be made to supply a 51-volt lamp circuit without changing the armature? J. M. Q.

1°. The rating of the fuse is probably at fault. It sometimes happens that when the rating of a fuse has been lost, its capacity is guessed at by comparing the diameter with that of other fuses whose rating is known. As the diameter of a 50-ampere fuse in one lot may be greater than that of a 75-ampere fuse in another, this has frequently led to trouble. 2°. No; by reducing the speed and strength of field, the voltage may be reduced, but with consequent sparking and total lack of regulation.

What is a booster and for what is it used? F. L. W.

A booster consists of an armature driven in a magnetic field and through whose windings passes the entire current of the circuit in which it is placed, its object being to increase the voltage of the circuit. Usually there is a combination of two direct connected machines, one of which acts as a motor and drives as a dynamo the other machine or booster. Sometimes there is a single field with the motor and booster windings on the same armature. A booster may be used on an incandescent lighting feeder leading to a distant point, in order to raise the E. M. F. of that feeder sufficiently above the station E. M. F. to compensate for its abnormal drop; or in an auxiliary storage battery installation to add sufficient E. M.F. to the dynamo voltage to charge the cells.

How can one or several coils be cut out of a G. E.-800 motor railway? L. M.

To cut out a coil from a G. E.-800 or Westinghouse Type 12 or any other motor, it is necessary simply to find the beginning and the end of the bad coil in question, and at the point where they make fast to the commutator, disconnect or cut them, joining the sprouts again by as short a piece of wire as will reach from the one to the other, the wire being of same size as that of the coils. In other words, disconnect the bad coil at each of its ends and replace that coil by a short piece of wire "or jumper," which may be laid in at any convenient place, usually as a half circle around the head of the armature. Do the same to each individual coil which is damaged. If a generator, the additional precaution is necessary of cutting the entire coil open at some convenient point and carefully insulating all of the ends where the cut is made. This is in order to prevent a local current being possibly set up in the damaged coil which would heat and burn it.

In "Lessons" in the October number it is stated that the maximum E. M. F. is generated in an armature conductor when it is passing through the strongest part of the field. In Thompson's "Elementary Lessons in Electricity" it is stated that the maximum effect occurs when a loop is passing through the pole gap, or the weakest part of the field. Which is correct? E. B.

Prof. Thompson is a partisan of the academic loop and flux, or induction, method of accounting for the generation of E. M. F., according to which, in a bipolar field, the E. M. F. is a minimum when the flux or induction through a loop is a maximum, and *vice versa*. If the mind is well enough trained mathematically to keep always in sight that the E. M. F. is the differential of the flux or induction, with respect to the angular velocity of the loop, this explanation will answer, but even then, it is much less satisfactory than Faraday's simpler conception of a single conductor cutting lines, of force, thereby and having generated in it an E. M. F. measured at any instant by the number of lines being cut at that instant. Both statements, however, are correct. Of course, in a constant-current machine the highest E. M. F. of the commutator is at the segments in the gap.

New Apparatus and Appliances.

A SIMPLE AMMETER.

In the descriptive notice, which appeared in our February issue, of a cheap and simple ammeter, an annoying error occurred, the names of the makers being wrongly given. The instrument described is made by the Cherry Electric Works, 25 Third Avenue, New York, and not by the firm whose name and address appeared in the article.

ELECTROMAGNETIC CIRCUIT BREAKERS.

In a recent paper read before the Northwestern Electrical Association, Prof. W. M. Stine, of Armour Institute, brought out very strongly the advantages of the electromagnetic circuit breaker over the metal fuse, which is both untrustworthy and slow of action. On the other hand, not only can the former be set so as to invariably break circuit for a fixed value of current, but the circuit is broken instantaneously. The conclusions of Prof. Stine are that circuit breakers should displace fuses in all places except in distribution boxes and for tap circuits.

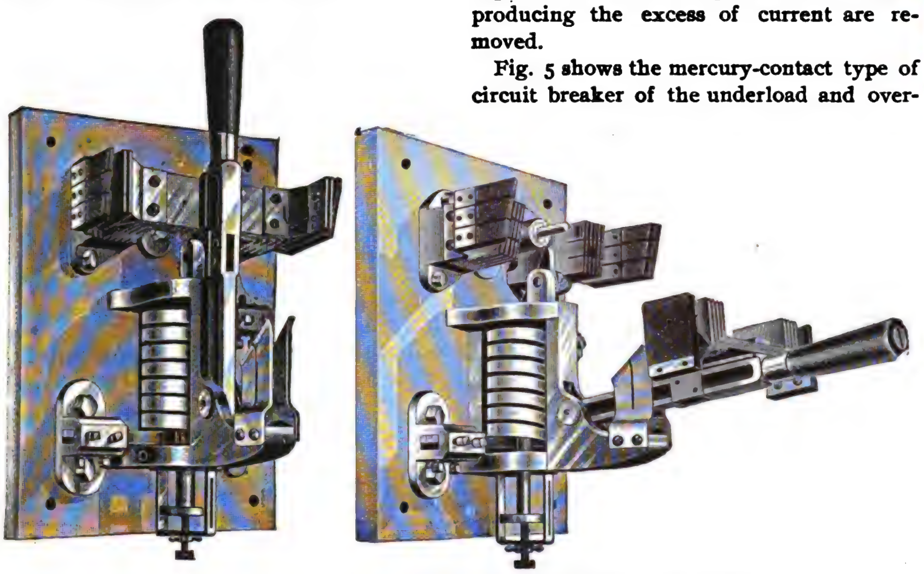


FIG. 1.—SINGLE-POLE SWITCH-BOARD CIRCUIT BREAKER.

In view of the growing recognition of the importance of the circuit breaker, we present herewith a number of illustrations of one of the best known types—the "I. T. E." In this type of circuit breaker a solenoid is used, as shown, which, when the current reaches a certain predetermined value, releases a catch holding a knife switch in circuit; the switch is then thrown by means of a striker, which acts upon a trigger. This trigger is so formed as to strike a hammer blow, and at the same time this blow is accentuated by a powerful spring which operates in the spring tube behind the switch.

The following descriptions and illustrations will furnish a general idea of the types of "I. T. E" circuit breakers best suited to different classes of work.

Fig. 1 illustrates a standard single-pole switch-board circuit breaker, suitable for lighting and power circuits and with slight modifications, for storage battery work.

In Fig. 2 is shown a double-pole circuit breaker, 80 to 600-ampere size, and, also represents the 800 to 1000-ampere, single-pole type.

Fig. 3 shows a standard alternating-current circuit breaker for feeder circuits, and service connections. By a slight change in the connections of this circuit breaker, it may be adapted to alternating-current generators. The coil in this type is connected directly to either the main dynamo leads, operating by the main current to open the field circuit by demagnetizing the generator.

Fig. 4 illustrates the mercury-contact type of circuit breaker, which is designed for service wires entering buildings, and for all mains carrying in excess of 10 amperes. Gravity and magnetism are the only forces used to operate it. The break is 5 ins., and while it can be instantly reset after opening, it will continue to open until the causes producing the excess of current are removed.

Fig. 5 shows the mercury-contact type of circuit breaker of the underload and overload type, which is designed especially for use in connection with motors. Its function is to open the circuit in event of an excess of current above normal requirements, as well as for opening the circuit should the power be shut off from the power house. The protection to motors is thus insured. This is, perhaps, one of the most important types.

From the above it will be seen that the range of manufacture of circuit breakers is very large, and we learn that about 1200 sizes and types are listed, including all varieties. The standard switch-board type has an actual rating of from 5 to 3000 amperes, according to size, in single-pole, and from 5 to 1500 amperes in double-pole, which range is constantly being enlarged.

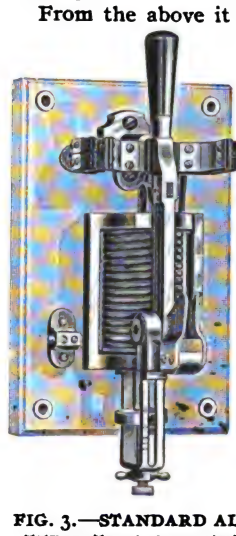


FIG. 3.—STANDARD ALTERNATING-CURRENT CIRCUIT BREAKER.

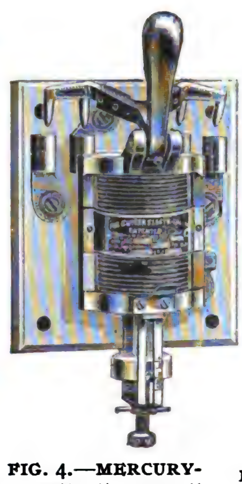


FIG. 4.—MERCURY-CONTACT CIRCUIT BREAKER.

A new circuit breaker, to be known as the "Midget," has recently been placed on the market by the same manufacturers. This circuit breaker is designed on new lines, but embodies the more important features of the original design. It will have a capacity of from 1 to 25 amperes and in its various forms is designed to meet the many requirements of heat, light and power circuits. It is made in overload, single and double-pole; in underload, single and double-pole; and also in these two combined.

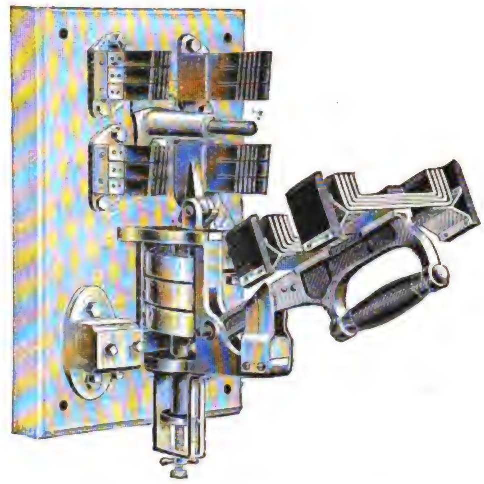


FIG. 2.—DOUBLE-POLE CIRCUIT BREAKER.

The price of the Midget is so small as to do away with the chief objection to the use of circuit breakers, i. e., price.

The "I. T. E." types of circuit breakers are manufactured by the Cutter Electrical & Manufacturing Company, 1112 Sansom Street, Philadelphia, Pa.

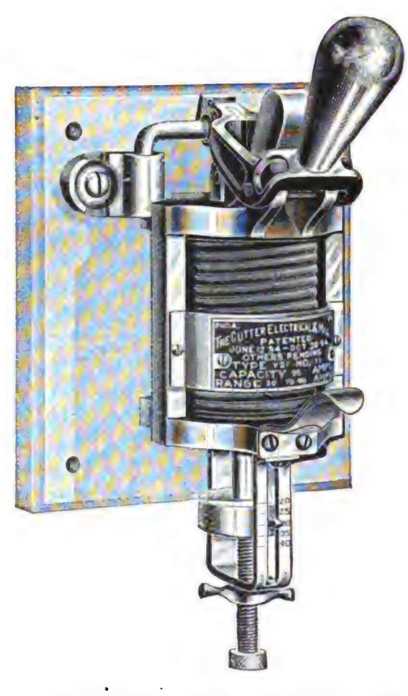
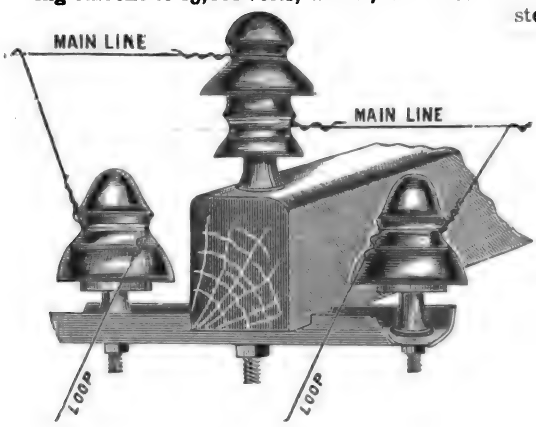


FIG. 5.—UNDERLOAD AND OVERLOAD CIRCUIT BREAKER.

TRANSPOSITION INSULATORS.

The accompanying illustration shows a type of transposition insulator and two-pin break-arm specially adapted for telephone lines where the highest of insulation is required. It has been used with much success for telephone lines run on the same poles with high-voltage long-distance power transmission lines, in one case the telephone line being strung within 4½ ft. of lines carrying alternating current of 15,000 volts, which, it is needless to say, is a very severe test. The insulator is applicable anywhere that two lines are fastened to one insulator, and aside from its high insulating qualities, is strong and durable. It is in use on the Cataract Construction Company's lines between Niagara Falls and Buffalo and hundreds of others.

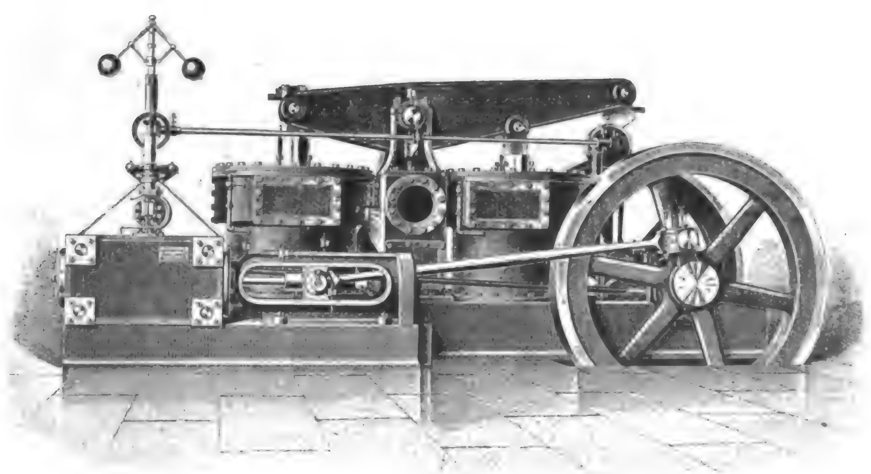


TRANSPOSITION INSULATORS.

The insulator and break-arm illustrated are made by Fred. M. Locke, Victor, N. Y.

JET CONDENSER WITH CORLISS VALVE GEAR.

Economy in the generation of steam power for electrical purposes is constantly receiving closer attention, and the auxiliaries to the engine are consequently no longer neglected in this respect. The jet condenser shown in the accompanying illustration is an example of the same principles of high steam economy that are applied to the prime mover itself.

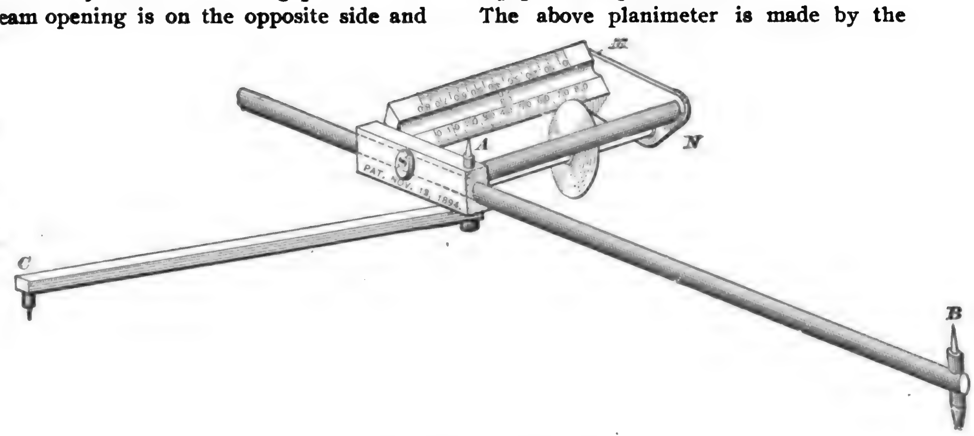

JET CONDENSER WITH CORLISS VALVE GEAR.

The engraving shows a 5000-HP jet condenser recently installed for the Atlantic Avenue Railway Company, of Brooklyn, N. Y., consisting of two vertical, single-acting air pumps, driven by a horizontal Corliss cylinder mounted on the same bed. The power is transmitted to the pumps by means of connecting rods, crank shaft and walking beam. The steam cylinder is placed on one side of the pump cylinder and drives on the crank pin fastening in one of the two fly-wheels.

The condensing chamber is located between the two pump cylinders, the top of which also supports the bearings of the walking beam. The condensing water is taken through the opening shown in cut, and is evenly distributed in the condensing chamber by means of baffling plates. The steam opening is on the opposite side and below the opening of the circulating water. The condensing chamber extends down through the base plate, and connects with the bottom of the condenser pumps. These pumps are of the single-acting bucket type provided with foot valves, with all parts in contact with the water made of brass or brass lined, as the condensing water used at this station is very acid. The steam cylinder is 12 ins. bore × 30 ins. stroke, and runs at a speed of from 25 to 50 r. p. m. The desired speed is obtained by changing the speed of the governor. The condenser is intended to take care of the steam from eight tandem compound Corliss engines, developing about 5300 HP.

The above condenser was made by The C. & G. Cooper Company, Mt. Vernon, O., which firm is also erecting two condensers of the same size for the Lowell & Suburban Street Railway Company, Lowell, Mass.

THE WILLIS PLANIMETER.



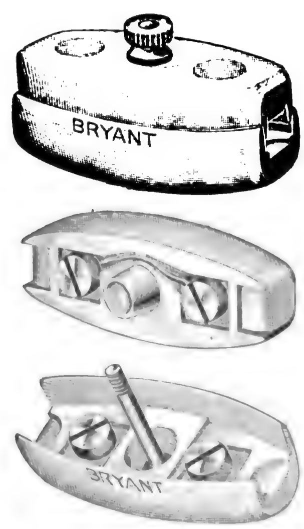
THE WILLIS PLANIMETER.

The accompanying illustration shows a planimeter for the measurement of areas and particularly, for obtaining the mean pressure of indicator cards. To measure an indicator card, the points, *A* and *B*, are set to the length of the card, the wheel is set opposite zero on the appropriate scale and the tracing point, *B*, moved over the lines of the card, the point, *C*, being fixed. The scale, *M*, has six graduated edges, thus corresponding to six different indicator springs. As the tracing point moves over the card, the wheel both rolls and slides on its axis, differing thus from the usual form of planimeter having a recording wheel parallel to the tracing bar, which wheel scrapes along the paper during its motion.

The above planimeter is made by the Buffalo Indicator Company, 50 Lakeview Avenue, Buffalo, N. Y.

BUG CUT-OUT.

The accompanying illustration shows in detail a new bug cut-out, for which a number of advantages are claimed. The security from short-circuit is one that will be appreciated by every electrician, as well as the facts that there is but one nut—and this a thumb nut—to remove, and no necessity for removing connecting wires to replace fuses. As will be seen from the illustrations, the fuse is placed in the cover instead of in the base, the connecting wires being in the latter. The illustrations show the cut-out in actual size.



BUG CUT OUT.

The cut-out described is made by the Bryant Electric Company, Bridgeport, Conn.

PORCELAIN LAMP BASE.

The desirability of a porcelain lamp base has long been recognized, and the electrician will therefore be gratified that such a base is now manufactured by a responsible firm. We give herewith an illustration of a standard lamp, fitted with the new base, which not only shows it to be thoroughly

artistic and well proportioned, but would indicate that the union of glass with a fine grade of glazed porcelain is much more effective than with brass.

The method of fastening the brass ring to the porcelain is ingenious, the union being so rigid that it is almost an impossibility to remove it. The point of insulation in this base is greatly superior to the old style of base, making it unusually desirable on a 220-volt system and valuable for use in street railway or out-door sign work, mills or cellars where acid fumes and damp or salt

PORCELAIN LAMP BASE.

air cause corrosion. The fact that it can be readily cleaned is also an advantage over the brass bases which tarnish very quickly—an advantage which can be appreciated by users of fine fixtures. Tests under varying conditions have been made, we are informed, by several of the largest manufacturers of lamps in the country, who have reported that the base is superior in every respect to the brass base.

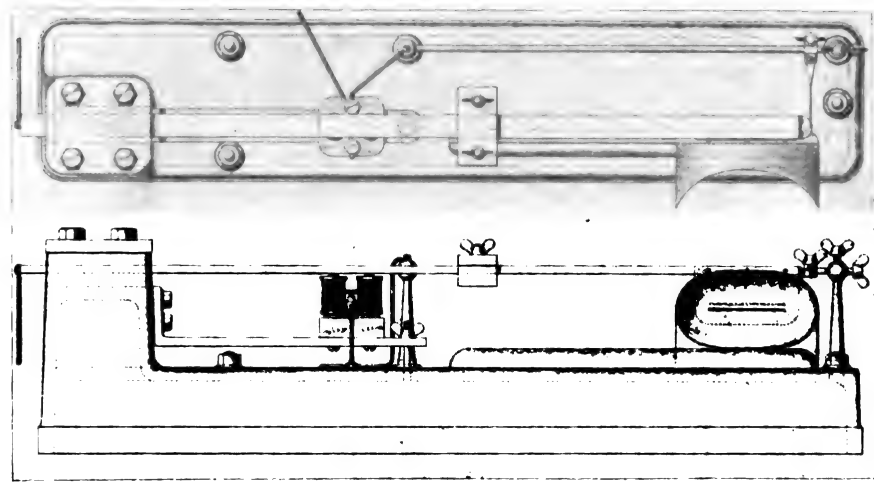
The above described base is made by the Bryant Electric Company, Bridgeport, Conn., by whom it is made only for the manufacturers of incandescent lamps; any requests for additional information should, therefore, be addressed to the latter.

VIBRATORY TACHOMETER.

An ingenious device used by the Ball & Wood Company in its testing shop, is shown in the accompanying illustration. By its means the slightest variation in the speed of engines can be detected, and the device is applied by the Ball & Wood Company to testing the speed of its engines under all conditions of load before they leave the shop, no governor being considered satisfactory which is thereby shown to have a variation exceeding 1 per cent. between no load and full load.

A plan and side elevation of this instrument are shown in the accompanying illustration. It consists of a rod supported at one end, and kept continuously vibrating by means of an electromagnet in a make-and-break circuit controlled by the vibrator. Any required number of vibrations can be obtained by changing the location of a weight on the vibrating rod. Toward the free end of the rod is a narrow slit. Immediately in front of this rod is placed a screen having a narrow opening corresponding in size and shape to the opening in the rod. As the rod vibrates it brings the two openings together at regular intervals.

When an engine is to be tested the instrument is placed a few feet to one side, and in such a position that an observer looking through the openings will see nothing but a spoke of the fly-wheel. The vibrator is then so adjusted as to give the proper number of vibrations corresponding with the speed at which the engine should run. This is the number of revolutions of the engine multiplied by the number of spokes in the fly-wheel. By starting the vibrator when the two slits and one spoke are in line any variation in engine speed can be made apparent by the departure of the spokes from the line of vision.



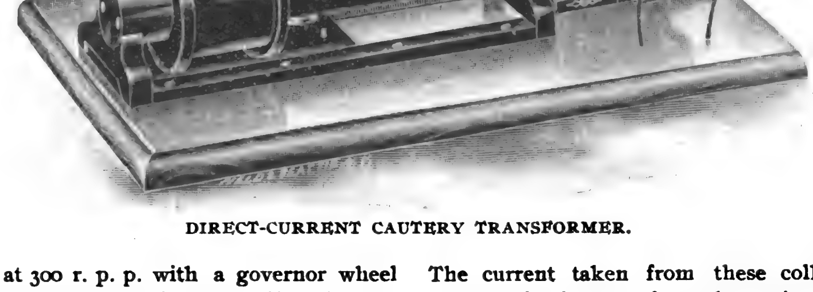
VIBRATORY TACHOMETER.

To make the method of operation more plain, suppose, for instance, an engine running at 300 r. p. p. with a governor wheel in which there are six arms. The observer standing at the side of the wheel and in front of the instrument looks through the narrow slit and sees the arms of the wheel as they pass. In the case assumed, if the rod is at rest with the two openings together, he sees what appear to him to be 1800 of these arms pass the opening every minute. Now, if the vibrating rod is adjusted so as to cover and uncover the opening in the screen at 1800 equal intervals per minute, it will appear to the observer that one arm remains stationary in front of the opening, but if there is the slightest difference between the arm intervals and the times of vibration, the arm will appear to move slowly across the opening in a direction depending on which interval is the greater.

DIRECT-CURRENT CAUTERY TRANSFORMER.

The apparatus illustrated in the accompanying engraving is designed to enable the direct 110 to 120-volt continuous current to be used with absolute safety for electro-cautery work, and will be found of great assistance to those physicians whose offices are equipped with this current. It is also suitable for hospital work as nearly all of the most prominent institutions are lighted from circuits of the above voltage.

It consists of a 120-volt Edison motor, the armature shaft of which is provided with two collecting rings which are connected to the armature at points diametrically opposed.



DIRECT-CURRENT CAUTERY TRANSFORMER.

The current taken from these collecting rings, which is now of an alternating character, is lead into the primary circuit of the transformer, shown on the left of the cut. The primary circuit is composed of a number of turns of fine insulated copper wire, wound round a core of annealed iron wires, the whole being enclosed in a thin cylindrical

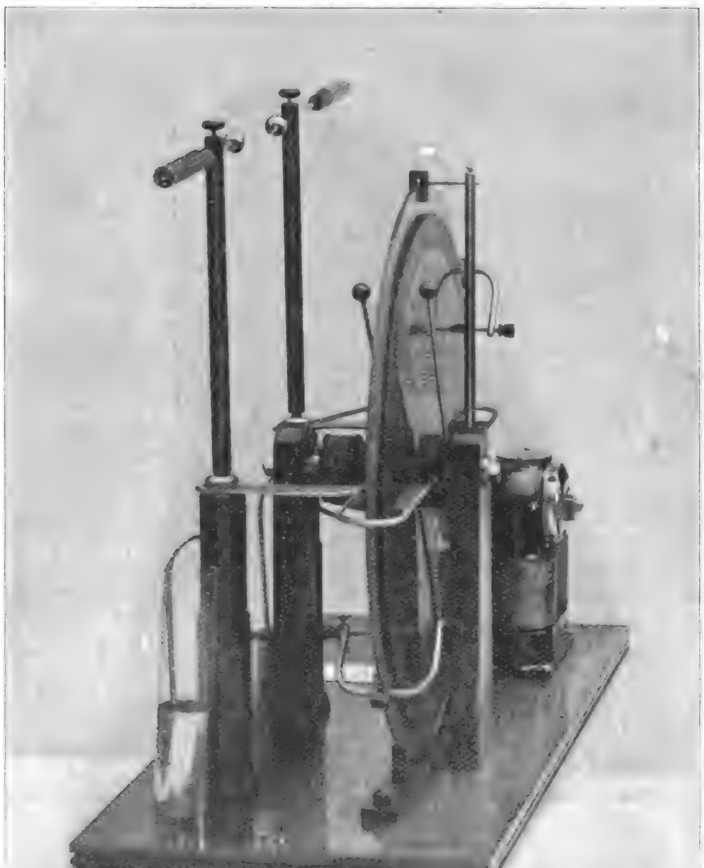
shell of hard rubber, which is supported by a hard-rubber standard at each end. The secondary coil, composed of a few turns of thick wire, is wound on a hollow hard-rubber spool operated by a rack and pinion movement and sliding over the primary coil. The terminals of the secondary coil are brought out to two pin attachments mounted on one head of the coil, and the cautery cords are connected thereto by split socket connections. On moving the secondary coil to the right, the current is increased, and vice versa. The apparatus is mounted on a highly polished oak base, and is provided with an attachment plug and ten feet of flexible cord for connecting the instrument to the mains.

The above apparatus is manufactured by the Edison Manufacturing Company, 110 East 23d Street, New York City.

STATIC RÖNTGEN RAY GENERATOR.

The static machine shown in the accompanying cut has been specially designed for use in connection with the generation of Röntgen rays, and is claimed by the makers to obviate the objections applying to most of the usual forms of static machines through their failure to discharge with sufficient rapidity to give deep penetration.

The working disks are made of hard rubber, which are of a size sufficient to produce the required length of discharge, and the high speed which can be given such disks increases the accumulation and the rapidity of discharge. As shown in the illustration, the machine is run by a constant-current motor mounted on the base plate, the entire outfit being normally enclosed in a dust and moisture-proof case. No trouble is experienced with this machine from reversal of polarity.



STATIC RÖNTGEN RAY GENERATOR.

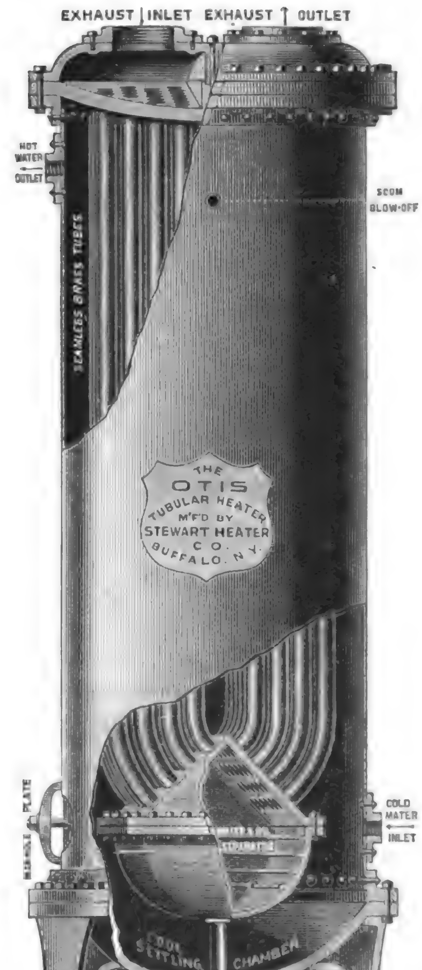
The above machine is made by the L. E. Knott Apparatus Company, 14 Ashburton Place, Boston, Mass.

FEED-WATER HEATERS AND PURIFIERS.

The accompanying illustrations show two types of feed-water heaters and purifiers containing a number of interesting features. The heating surface of the type illustrated in Fig. 1 is furnished by smooth, seamless drawn brass tubes, which have the advantage over copper or iron tubes of not becoming heavily coated with a sediment, but remain comparatively clean. The exhaust steam enteres the heater at the top, passes down through the left-hand section of tubes into an enlarged space at the bottom, where the water and oil are separated, and then up the right-hand section of the tubes to the outlet, whence it can be taken for heating purposes or exhausted direct into the atmosphere.

The water enters the heater at the opening to the right of the bottom of the cut, and circulates upward in contact with the heated tubes, thus gradually becoming thoroughly heated; it is then drawn out at the outlet marked in the upper left-hand side of the cut, this outlet being below the level of the water, in order to avoid carrying off scum that may be floating on the surface. It will be noted that the shape of the tubes is such as to allow of contraction and expansion, without bringing undue strain upon the tube plates. The sloping top of the water and oil separator does not retain sediment, which gradually settles away from and below the tubes into the coal settling chamber at the bottom of the heater, where it will not bake on, but can be washed out easily and quickly. This heater is guaranteed to heat the feed-water as hot after being in use several years as when new.

The heater shown in Fig. 2 is composed of a series of cast iron sections, each section being a unit; the sections have the form of a circular ring, and are so constructed as to withstand great pressures. Each section forms a spiral through which the water must circulate one full revolution before it passes into the next, thus bringing the water in contact with all of the heating surface; each ring has a large opening in the center, and also a series of passages cast through it, which not only add materially to the heating surface, but very largely increase the strength of the sections.



FIG; 1.—FEED-WATER HEATER.

The exhaust has a free passage around and through each section, thus completely surrounding and imparting its heat to the water. The water enters at the bottom, and after circulating through each section, passes out through the top of the boiler. The sections are secured together with heavy brass nipples, as shown in the illustration. At the top is a packing box which permits the sections to expand or contract freely without introducing harmful strains.

Both of the heaters above described are

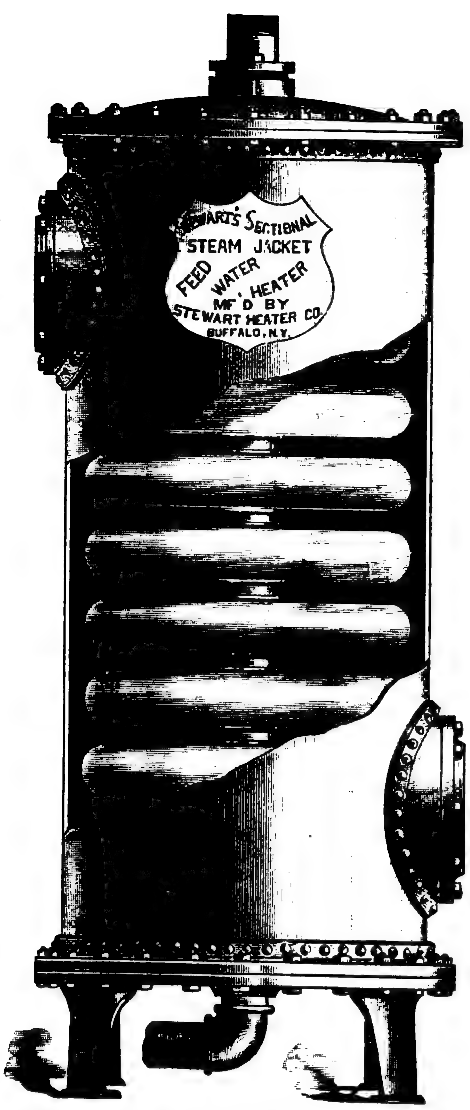


FIG. 2.—FEED-WATER HEATER.

made by the Stewart Heater Company, Buffalo, N. Y.

PERSONAL.

Mr. B. J. Arnold will deliver a series of ten lectures at the University of Nebraska, on the subject of "Central Station Design and Construction."

Mr. Fred M. Bathurst, formerly with the General Electric Company, at Schenectady, and now with its British name sake, has obtained from the Society of Arts its silver medal and a premium of £25, for a paper on "Fire Prevention." Mr. Bathurst returned to England to introduce the use of "interior conduit" in Great Britain, and in this he has met with much success. His principal rivals were those favoring concentric wiring, but at meetings of professional bodies where the subject came up for discussion and in the columns of our English contemporaries, Mr. Bathurst brought out so well the merits of the American system that its status is now assured, both technically and commercially.

NEW BOOKS.

THE A B C OF THE X-RAYS. By William H. Meadowcroft. New York: The American Technical Book Company. 189 pages, 37 illustrations. Price, 75 cents.

This is the best popular treatise on Röntgen rays that has yet come to our hands. The author has had much experience in Röntgen ray work, so that the book differs from most others on the subject in not being merely a compilation. The chapter on manipulation will be found particularly useful, as in it are given explicit directions for making radiographs, with much information on practical points concerning the action of the vacuum tubes employed for this purpose. The chapter on photographic plates and developers is also practical and explicit.

ELECTRIC STREET RAILWAYS. By E. J. Houston and A. E. Kennelly. New York: The W. J. Johnston Company. 367 pages, 158 illustrations. Price, $1.

The object of this volume of the electro-technical series, as stated in the preface, is to dispel the mystery with which the popular mind surrounds the electric railway, and show that the difficulties to its understanding are apparent rather than real—that it is quite possible for the general public to obtain a fairly intimate knowledge of electric traction witht out any previous knowledge of electro-technics. In this task we believe the authors have been successful. The volume will answer a very good purpose within the limits implied, and at the same time furnish to the student and others an excellent firsbook on the subject of which it treats.

AMERICAN TELEGRAPHY. Systems, Apparatus, Operations. Second edition. By William Maver, Jr. New York: William Maver & Company. 573 pages, 450 illustrations. Price, $3.50.

No electrical library is complete without this excellent manual of the telegraph, which includes within its scope railway block signaling systems, police signal and fire alarm telegraphy, electric burglar alarm systems, time telegraph service, heliography, the American district telegraph messenger service, as well as chapters on the manufacture of wire, construction and maintenance of telegraph lines, underground conduits and telegraphic specifications. The part devoted to telegraphy, in the usual sense of the word, is exhaustive in its treatment every form of duplex, quadruplex, submarine, automatic, writing, printing, multiplex and induction telegraphy being represented. Few, if any, arts are so well represented by a manual as is telegraphy in this compendious volume.

ELECTRICITY AND MAGNETISM. Lessons of the National School of Electricity. General Course. Second Edition. Fifth thousand. Chicago: Chicago School of Electricity. 324 pages, 347 illustrations. Price, $2.

Intended for the instruction of students of electricity who have had no previous scientific or mathematical instruction, this work answers a useful purpose. The chapters or "Lessons" are preceded by a series of questions by means of which the student can review the subject treated. With several exceptions, each of the 34 chapters of the book treats of a different subject, alternating between descriptive notices of appliance and apparatus and simple explanations of electrical principles. The text has been prepared by competent writers, and the work can be recommended with confidence to practical men who desire to obtain a considerable electrical knowledge and to whom the usual text-book methods of instruction do not appeal on account of their academic character. The book is profusely illustrated, mostly, however, with trade catalogue cuts that add but little to the appearance or value of the pages.

ELECTRIC POWER TRANSMISSION. A Practical Treatise for Practical Men. By Louis Bell, Ph.D. New York: The W. J. Johnston Company. 491 pages, 229 illustrations. Price, $2.50.

This work is in many respects an ideal treatise within the limits set in the title "A Practical Treatise for Practical Men." As the author states in his preface, "Busy men have little time to spend in discussing theories of which the practical results are known, or in following the derivations of formulas which no one disputes," and he therefore confines himself to presenting the present state of electrical power transmission with only such reference to theory as is necessary for a proper understanding of the main underlying principles. Three chapters are devoted to general principles, the one on alternating currents being an extremely satisfactory and practical treatment of that subject. Two chapters follow on the general aspects of power transmission by continuous and alternating currents, and the remaining pages are mostly devoted to a practical engineering treatment of the various problems encountered in the electrical transmission of power. Three valuable chapters are on the line, line construction and centers of distribution. Current reorganizers is the subject of a chapter and two others are on hydraulic development and the organization of a power house. The final chapter—and one of the most important in the book—is on the commercial problem of electrical power transmission.

THEORY AND CALCULATION OF ALTERNATING-CURRENT PHENOMENA. By Charles Proteus Steinmetz, with the assistance of Ernst J. Berg. New York: The W. J. Johnston Company, 431 pages, 184 illustrations. Price, $2.50.

This volume undoubtedly forms the most important contribution yet made to the practical side of electrical science. It performs the same service toward the alternating-current branch of electrical engineering that Rankine's great pioneer works on steam and applied mechanics did toward steam and other branches of engineering, transforming, like the latter books, the highly abstract science of the mathematician and physicist into shape for direct engineering application. The book requires a mathematical education for its reading; the system of complex quantities used is so clearly explained at the commencement that its understanding is a simple matter, but otherwise the mathematical knowledge necessary is not as great as that required in the reading of the usual text-book on alternating currents. All alternating-current phenomena encountered in practical work are submitted to calculation, and a most commendable feature of the book is the illustration of the equations deduced by numerical examples employing practical data. To those who do not care to follow the mathematical portion of the book a mine of information will be furnished in the explanations of apparatus and phenomena; remarks and discussions concerning the practical bearing of deductions, etc. Mr. Steinmetz by thus giving to the world the benefit of his unrivaled knowledge of alternating currents—obtained from experience in practical design as well as in theoretical research—has conferred a lasting favor on the electrical engineering profession.

TRADE PUBLICATIONS.

The Walker Trolley. Circular No. 1030 of the Walker Company is devoted to a description and illustration of its roller trolley. All of the various parts are separately illustrated and the many advantages of the roller trolley enlarged upon.

Refrigeration. Westinghouse, Church, Kerr & Company, 26 Cortlandt Street, New York, have issued a handsome pamphlet of which ammonia refrigeration forms the subject. The various parts of a refrigerating plant are illustrated in detail and a number of excellent half-tone views given of plants in operation.

Enclosed Arc Lamps. In a handsomely printed pamphlet issued by the General Incandescent Arc Light Company, 527 First Avenue, New York, the 1897 styles of Bergmann long-life enclosed arc lamps are described and the standard forms illustrated. Among the matter contained are some useful hints as to the selection of globes for arc lamps.

Transformers. The General Electric Company has reprinted for distribution a paper on "A Complete Test of Modern American Transformers," by Mr. Arthur Hillyer Ford, which formed Bulletin No. 11 of the University of Wisconsin. The methods employed in testing are described in detail and the data both tabulated and plotted. The pamphlet altogether forms an important contribution to the literature of the transformer.

Electric Pumping Machinery. In a beautifully printed and illustrated pamphlet the General Electric Company sets forth the advantages to be gained by the use of electricity in pumping. The pamphlet, which is from the press of the General Electric Company at Schenectady, is a fine specimen of the the engraver's and printer's art. The score or more of well executed half-tone engravings contained illustrate almost every variety of pumping plant, the more important of which are described in the text.

Ball and Roller Bearings. In a 28-page pamphlet the Ball Bearing Company, Watson Street, Boston, Mass., illustrates and describes the numerous forms of ball and roller bearings of its manufacture. The sizes and shapes of bearings made are so varied that there would seem to be little difficulty for one to be selected that could be simply and cheaply fitted to almost any machine. We note one type of ball bearing hub especially adapted for static electric machines, and made in two sizes—one for a two-plate, and the other for a four-plate hub.

Electric Lamp Shades. "Green and White" is the title of a little pamphlet issued by the Westing-

house Glass Works, Allegheny, Pa., in which is illustrated a number of shapes of incandescent lamp shades of composite glass—green outside and white inside. Among these is a disk reflector in which green glass replaces the gilding of the older type of the same shape. The Westinghouse factory is to be congratulated upon having not only equaled but improved upon a line of glass manufactured that heretofore it has been necessary to import from Europe.

Electrical Mercantile Agency. The electrical trades will be interested by a handsome little pamphlet issued by the Electrical Mercantile Agency, 318 Broadway, New York, in which the methods of this special commercial agency for the electrical trades are explained. With over 10,000 correspondents and the ratings of between 12,000 and 15,000 concerns in its "Trades Credit Reference Book," this agency has every reason for its claim that it offers facilities superior to the general commercial agencies to those engaged in the electrical trade.

List of Electrical Plants. In a recent pamphlet the Siemens & Halske Electric Company, Monadnock Block, Chicago, gives a partial list of the plants installed by it in the United States, numbering some hundreds and including some of the most important installations yet made, such as that of the Siegel-Cooper Company, of New York. The lists are classified according to the type of machine, including external-armature machines, bipolar belted machines, railway generators and miscellaneous. The final pages of the pamphlet are devoted to testimonials, which are all extremely favorable and most from sources that add weight.

BUSINESS NEWS.

The Elektron Manufacturing Company has moved its office to 143 Federal Street, Boston, Mass.

The Playford Stoker Company, Cleveland, O., has just installed one of its mechanical stokers under a 250-HP water tube boiler, at the Allegheny Water Works.

The Ajax Arc Lamp Company, 43 Cortlandt Street, New York, has been formed with a capital stock of $100,000. The directors are B. H. Pomeroy, E. Woltmann, L. E. Shinn, D. H. Gildersleeve, A. Kirkham, J. Lowenthal and C. S. Van Nuis.

The Standard Air-Brake Company has secured the services of Herbert B. Taylor, at present with the Consolidated Traction Company, as chief assistant in the electrical department to F. Uebelacker. Mr. Taylor entered the service of the Standard Air-Brake Company on Mar. 1.

The Ball Engine Company, Erie. Pa., is installing for the Wilmington Gas Light Company, Wilmington, N. C., a 350-HP horizontal cross compound engine. A 60-HP engine, direct connected to a 25-HP General Electric dynamo, has been recently placed in the Church Home & Infirmary, of Baltimore, Md., by Crook, Horner & Company, representing the Ball Engine Company.

The Eastern Electrical Supply Company, has taken quarters at 26 Cortlandt Street, New York. The officers of the company are B. H. Ellis, president and manager; C. P. Scott, vice-president and secretary, and C. L. Hills, treasurer. A wide experience in the electrical business, extending over ten years, renders these gentlemen experts in their line, which will comprise all manner of electrical supplies.

Mr. Thomas Hill, Jr., 128 Water Street, New York, has found it necessary, on account of the growing demand for desk telephones, to get up any instrument for office use which is claimed to be not only one of the prettiest telephones of its kind on the market to-day, but to positively have the best carbon-dust transmitter made. A circular showing the appearance of this apparatus will be sent on application.

The American Engine Company, of Bound Brook, N. J., has just secured the order for the entire engine equipment of the new station of the Scranton Illuminating Heat & Power Company to be built on the site of the old station, recently destroyed by fire. The equipment will consist of six American-Ball engines, five of which will be compound and one simple. Direct-connected generators will be used on four of these engines, and the station will be modern in all its appointments.

The Utica Electrical Manufacturing & Supply Company, Utica, N. Y., has secured a contract from Hugh Glenn & Company, of that city, for the placing of forty long-burning Manhattan arc lamps in their stores, 54, 55, 58 and 59 Franklin Square, they having decided to throw out the incandescent lamps and to equip the entire store with 150-hour arc lamps. These lamps were only adopted after a trial of different types by Mr. Arthur Kassing, the engineer, who considers that it is the most economical, gives a brighter light and is easily cared for.

The Western Electric Company, of Chicago and New York, has a complete line of high-grade fan motors ready for the beginning of the season. Among those are a 16-in. fan and 12-in. fan, both mounted upon a wall bracket or stand as desired. The stand for the 16-in fan is either adjustable or rigid, but that of the 12-in. is made in the rigid style only. These fans have three speeds. There are also a column and a ceiling fan, each with two speeds. All of the fan motors are designed for three different voltages, namely, 110, 220 and 550, direct current.

The American Rheostat Company, Milwaukee, Wis., has secured the services of Mr. F. E. Herdman as general manager. Mr. Herdman was until recently with the Crane Elevator Company, of Chicago, and his ability as an electrical engineer is well known. The Company is moving into quarters considerably larger than those which it now occupies in order to be enabled to keep up with the demand for its output. A complete and improved line of elevator controllers, crane controllers, automatic pump starters etc., of its manufacture will shortly be placed on the market.

Graphite for Resistance Purposes. For some years the Joseph Dixon Crucible Company, Jersey City, N. J., has been supplying graphite resistance devices in quite a large way to telephone companies, electric light companies and electricians generally. The resistances have been so satisfactory and the demand so promising that it has now added to that department of its works a dynamo and all necessary apparatus for testing purposes, and is prepared to furnish graphite resistances in round or square rods, tubes, spirals and other devices as wanted, of 1 ohm or 1,000,000 ohms resistance, as required.

The Westinghouse Machine Company, Pittsburgh, has sold to the Tennessee Centennial Exposition Company, four Westinghouse compound engines, each 400-HP. The engines will be installed in the Exposition Company's power plant. The Westinghouse Machine Company's foreign business steadily increases. The Paris agency recently sold four Westinghouse compound engines, aggregating 1100 HP., for electric railway service in Russia. A repeated order has also been received from the International Electric Company, Liege, Belgium, three compound Westinghouse engines of 300 HP each, and one of 100 HP.

Water Wheel Governors for the Minneapolis Plant. The Lombard Water Wheel Governor Company, of Boston, has closed a contract with the St. Anthony Falls Water Power Company, of Minneapolis, to furnish seven governors for the new plant which the latter is building. These seven governors are to regulate four water wheels each, or twenty-eight water wheels in all, aggregating 10,000 HP. The style of governor to be employed in this plant is designated by the manufacturer as Type C. During the past year the Lombard Company has installed this type of governor on over 40,000 HP of water wheels. On account of the magnitude of the Minneapolis plant, the question of governors was very carefully looked into before the above order was placed.

Packard Lamps. The manufacturers of the Packard lamps have always had the reputation of doing something very handsome in the catalogue line, and this reputation has been maintained by the appearance of their catalogues for the season of 1896-1897. This catalogue is a little more pretentious than any of its predecessors, and a goodly number of its pages are devoted to general data on incandescent lamps and other general information of a valuable nature. The Electric Appliance Company, of Chicago, has prepared a special discount sheet for this catalogue, giving the present market prices on high grade Packard lamps, so that the catalogue when supplied with this discount sheet makes a complete lamp reference book. It will be sent to the trade on application.

The Fischer Foundry & Machine Company, of Pittsburgh, Pa., builders of the "Fischer" single and four-valve engines, desires to contradict certain unfounded reports that have been in recent circulation, to the effect that the manufacture of engines has been discontinued by the company. On the contrary, it may be stated that additional features have been introduced, which, combined with the already known merits of the original makes of these engines, especially adapt them for electric and street railway purposes. An inspection of the company's shops in Pittsburgh reveals a thriving and prosperous industry, and the business outlook for 1897 is flattering. Foster & Louis, general Western agents, have offices at 1000 and 1002 Fisher Building, Chicago, where the many friends of the Fischer engine, and in fact all visitors, will be cordially welcomed.

The Louis K. Comstock Company, of Chicago, made an assignment recently in order to protect all its creditors alike. The assets, however, are $53,000 and liabilities only $35,000; hence, it is expected that all the debts will be paid in full with interest and that the business will be resumed under the old company name in a short time. This news will be very welcome to the many friends of the company, as its president, L. K. Comstock, and secretary, F. S. Richmond, have a very enviable reputation in the West as engineers and contractors, and have been identified with that branch of the electrical business for many years. Many of the largest and finest isolated plants in the West have been installed by the company during its business career. Until the reorganization is effected, the business will be conducted under the firm name of Comstock & Richmond, with offices at 1108-9 Ft. Dearborn Building.

Carbon Electrodes. The importance of a suitable carbon electrode for industrial electrolysis becomes evident with the increasing production by electrolytic methods of either chemicals or metals in this country. Mr. Hugo Reisinger, of No. 38 Beaver Street, New York, who is well known to the electrical trade for his "Electra" arc light carbons, has had great success in the introduction of his carbon electrodes, which are used in the electrolytic production of aluminum, copper, chlorate of potash, etc. The carbon electrodes supplied by him are made of pure carbons. They are homogeneous throughout, of the very highest conductivity, and give a very great life. The European factory which Mr. Reisinger represents in this country has the greatest facilities for turning out large quantities of these carbon electrodes, and among others, has a running contract to supply all the carbon electrodes used in the world-renowned aluminum factories at Neuhausen, Switzerland.

The Metropolitan Electric Company, of Chicago, has been given the Western agency of the electric heating apparatus made by Messrs. Whittingham & O'Brien. This line covers domestic laundry and tailors' irons of all kinds, electric heaters (radiators), etc., etc., etc. The company reports a growing demand for this class of goods, and especially for electric laundry irons. The extended use of electric lights in hotels and apartment buildings, has done much to further the sale of these most convenient articles. The irons are arranged with stranded socket so that it is only necessary to unscrew the incandescent lamp and insert the socket which is attached to the heater, and the apparatus is ready for use. The Metropolitan Electric Company has also taken the agency of the Reynold self-adjusting bug cut-out. This consists of two pieces of porcelain so recessed and put together as to entirely cover and connect the fuse wire and connections.

American Electrician.

Vol. IX. New York, April, 1897. No. 4.

A PUBLIC PARK LIGHTING PLANT.

BY P. M. HELDT.

THE most complete and extensive plant yet installed for the exclusive purpose of furnishing electric illumination for public parks, has recently been completed at Chicago. The new plant supplies current for the chain of parks and connecting boulevards (Fig. 4) situated on the west side of Chicago, and is located in the northwest corner of Garfield Park. The designs were prepared by Mr. Foree Bain, who also supervised the construction of the plant. The ultimate capacity of the plant is 1350 2000-CP arcs and 1200 16-CP incandescent lamps.

The power house (Fig. 3) is a stately building, combining architectural elegance with a thorough adaptiveness to the purpose it has to serve. It is constructed of buff-colored pressed brick, with stepped gables of moulded and carved buff Bedford stone, cornices of copper, and a roof of red tile. The smoke-stack is built of steel, 164 ft. high, and is set in a solid foundation of brick and stone, which gives it the requisite support, and at the same time unites it with the building proper. At the west end of the building is located a coal shed holding 125 tons.

The boiler room (Fig. 6) occupying the west end of the power house, contains four water-tube safety boilers, set in two batteries, each battery being rated at 500 HP upon the basis of an evaporation of 30 lbs. of water per HP hour, at a steam pressure of 125 lbs. The boilers, which were furnished and set by the Standard Boiler Company, are suspended on steel I-beams, and are free to expand and contract independently of the brick setting. They are provided with Butman smokeless furnaces, in which the process of combustion reaches such a degree of perfection that practically no smoke passes out of the stack. Both the pressure and water gauges are placed very conspicuously, and the latter can be illuminated either by incandescent lamps or gas jets, in addition to the regular arc illumination of the boiler room. The boiler room is 60 ft. wide, by 69 ft. in length, and the walls are 25 ft. high. The floor is of Portland cement concrete, and the walls of cream enameled brick up to a height of 6 ft., above which buff-colored brick is used. It must be said of the boiler room that it is a model of neatness.

The engine and dynamo room (Figs. 1 and 2) is 60 ft. wide, by 88 ft. in length and is separated from the boiler room by a fire wall, floor and walls being the same as in the boiler room. The engines are set on raised platforms 2½ ft. above the floor. There are installed two cross-compound, condensing Corliss engines built and erected by the Filer & Stowell Company, of Milwaukee. They

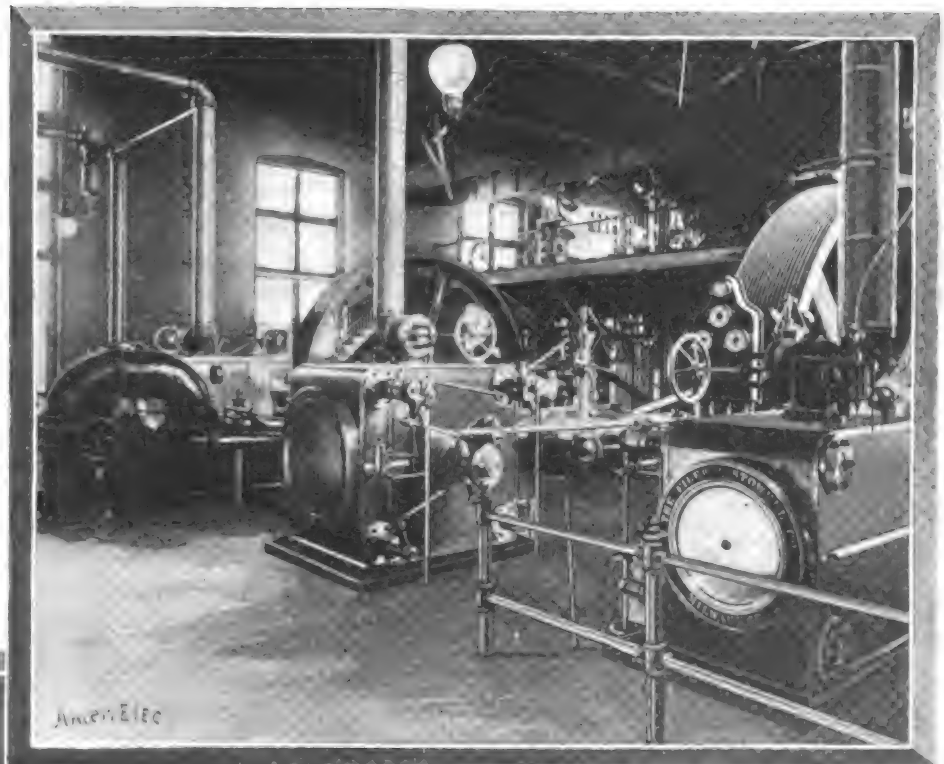


FIG. 1.—DYNAMO ENGINES.

FIG. 2.—DYNAMO ROOM.

are rated at 550 HP each when operating at best economy with an initial steam pressure of 125 lbs. per square inch. The speed of the engines is 72 r. p. m. The diameter of the high-pressure cylinder is 27 ins., that of the low-pressure cylinder 36 ins., and both pistons have a common stroke of 48 ins. Both the high and low-pressure cylinders of each engine have steam-jacketed walls and cylinder heads. The receiver is of special construction and provided with reheating tubes. The steam and exhaust valves of both high and low-pressure cylinders are of the double-ported type, the low-pressure cylinder exhaust valves being driven by a separate eccentric. The governing arrangement is of a specially interesting construction, the high and low-pressure valve gear each standing under control of a separate governor. These governors

are of the inverted, weighted, medium-speed type, and are not driven by a belt, as usually the case, but by a special gear shaft.

The general arrangement of these engines is such that either the high or low-pressure side can be run independently as a single cylinder engine, either condensing or non-condensing. The fly-wheels are 20 ft. in diameter, weigh 32 tons and are grooved for seventeen 1¼ in. ropes.

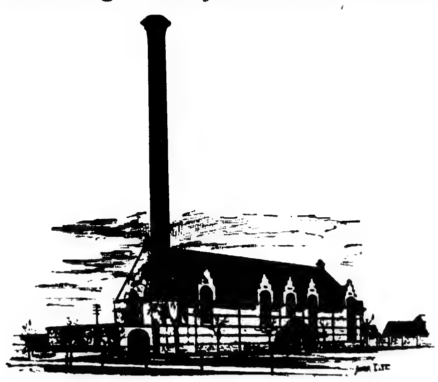


FIG. 3.—POWER HOUSE.

In appearance these engines leave an impression of great strength and compactness of design, together with thoroughness in constructive details. Since the starting of the plant they have given uninterrupted and highly satisfactory service.

Between the two engines is located a surface condenser of 1500 sq. ft. cooling surface, and a pumping engine for circulating the water through the condenser. The condensing water is taken from one of the lakes in the park and returned to another.

The American system of rope driving is employed. The main reason for using the rope-driving system is to avoid the static electricity of belts, which is thought by those who had charge of the design to be the cause of a good many accidents to dynamos. The jackshaft, running at 300 r. p. m., is located in a specially constructed vault. The pulleys are connected to the shaft by friction clutches operated by hand wheels through the intermediary of a worm-wheel gearing. The track of the tension carriage is fastened to the ceiling. The two engine drives consist each of seventeen wraps of 1¼ in. manilla rope running at a speed of about 4700 ft. per minute. There are two sizes of dynamo drives, one for the arc dynamos, consisting of six wraps, and the other, for the incandescent dynamo, of five wraps. Both are of ¾ in. manilla rope and run at a speed of 5000 ft. per minute. The American system is a double-wind system.

Directly above the jackshaft and tension carriages is a so-called mezzanine floor, which carries the dynamos. This floor is supported on steel beams having an independent foundation, so that any vibration due to the dynamos is not transmitted to the building.

There are at present installed seven 150-light Excelsior arc dynamos and one 60-KW two-phase alternator, manufactured by the Excelsior Iron Company, of Chicago. The arc dynamos are of the closed-coil series type and have forty-eight sections in armature and commutator. The commutator is air-insulated, the copper bars being screwed to a disk of marble. These dynamos run at a speed of 650 r. p. m., and give a constant current of 10 amperes at a maximum pressure of 7500 volts. The regulation is automatic, and is effected by shifting the brushes and simultaneously varying the field strength. The mechanism for moving the rocker and the field connection is driven by a small motor, the magnetic flux of which is shunted around the main armature. The armature of this motor is connected, one way or the other, to the terminals of a German silver resistance in the main circuit, through the action of an electromagnet, also in the main circuit. The resistance electromagnet and contact device are arranged in a regulator box attached to the switchboard.

Each dynamo is connected to the switchboard by five cables passing through the floor in brass tubes, standing about 6 ft. out above the floor, and then below the floor to the back of the switchboard. Two of these cables are the mains, two connect the regulating motor to the regulator box, and the fifth one connects the inner terminal of the field winding to an automatic switch which short-circuits the field winding of the dynamo whenever the current rises above or falls below certain fixed limits, for which limits the switch can be set. The dynamos are arranged in two rows with the jackshaft below midway between the rows. A traveling crane of 4000 lbs. capacity has been provided for handling armatures and other heavy parts of the dynamos. The track of this crane is fastened to the iron rafters supporting the roof.

The switchboard is of white marble in a polished brass frame, and is divided into four sections, three for the arc circuits, and one for the incandescent circuits. It is arranged for six arc circuits and by means of the usual flexible connectors any dynamo may be connected to any circuit, and any two circuits may be connected in series. There is provided for each side of each circuit a Weston station ammeter reading to 15 amperes in either direction. Magnetic blowout lightning arresters, with adjustable striking plates, are connected to the mains just before leaving the station. These lightning arresters are fastened to the wall behind the switchboard.

The alternator runs at a speed of 1000 r. p. m. and has ten poles, thus giving a frequency of 10,000 alternations per minute. The magnetic circuit of this machine closely resembles that of the Oerlikon three-phased generator used at the famous long distance transmission at Lauffen. There is but a single field coil on the moving part, with poles overlapping from either side. The exciter armature is carried by the main shaft. The pressure of this machine is 2000 volts effective, and is regulated by means of a graphite rheostat in the exciter field circuit. The rheostat is connected to the back of the switch-board. There are also connected to the back of the switch-board two small transformers, one for each phase of the current. A potential indicator of the well-known Shallenberger solenoid type can be connected to the secondary of either transformer by means of a switch. In addition to the potential indicator the alternating panel of the switch-board carries an ammeter of the same type, and the high-tension fuses. The switch-board was constructed by the Western Electric Company.

The arc mains consist of rubber-covered, lead-armored cables drawn into pump-log conduits. These conduits are laid under the grass plots along the boulevards and drives in the parks, about 12 ins. below the surface. The total length of the arc cables is 400,000 ft. and the size of the conductor somewhat larger than No. 5 B. & S. The lamps are placed about 750 ft. apart. The poles consist of two parts, the lower of wood and the upper part of iron. The lead-ar-

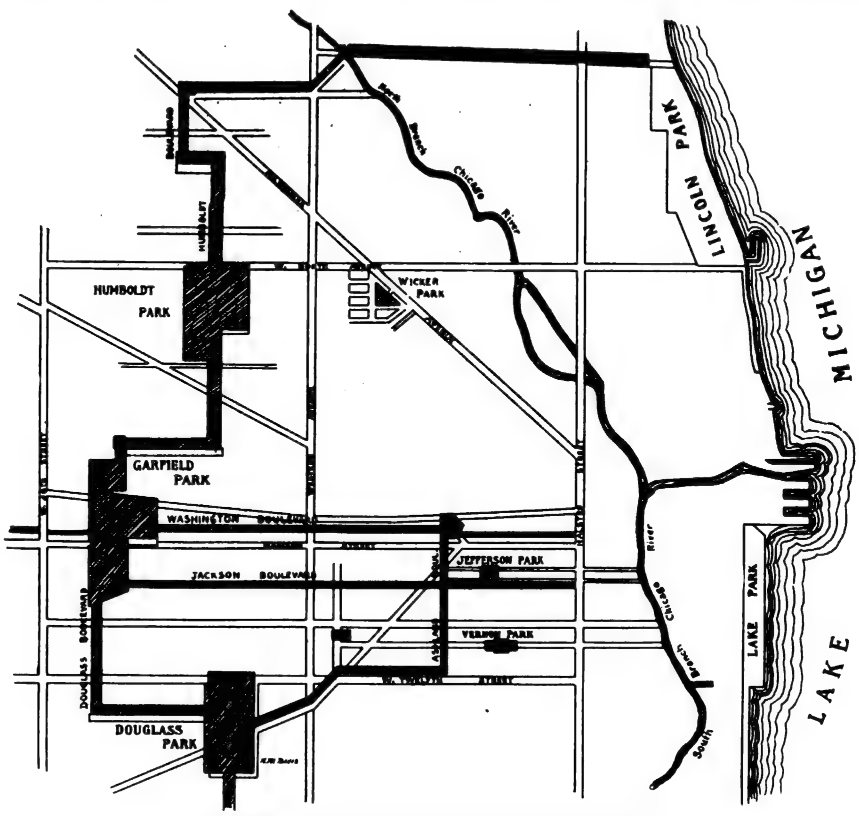


FIG. 4.—MAP OF PARKS AND BOULEVARDS.

mored cables are drawn into the lower part of the pole where they connect to the lamp switch. From the switch cables similar to the mains, but without the lead sheathing, lead up to the lamp. There are two circuits on each boulevard and alternate lamps are connected to the same circuit. This arrangement permits of reduction of the illumination at midnight or some other convenient hour. The lamps, which are of the Adams-Bagnall type, are very ornamental in appearance.

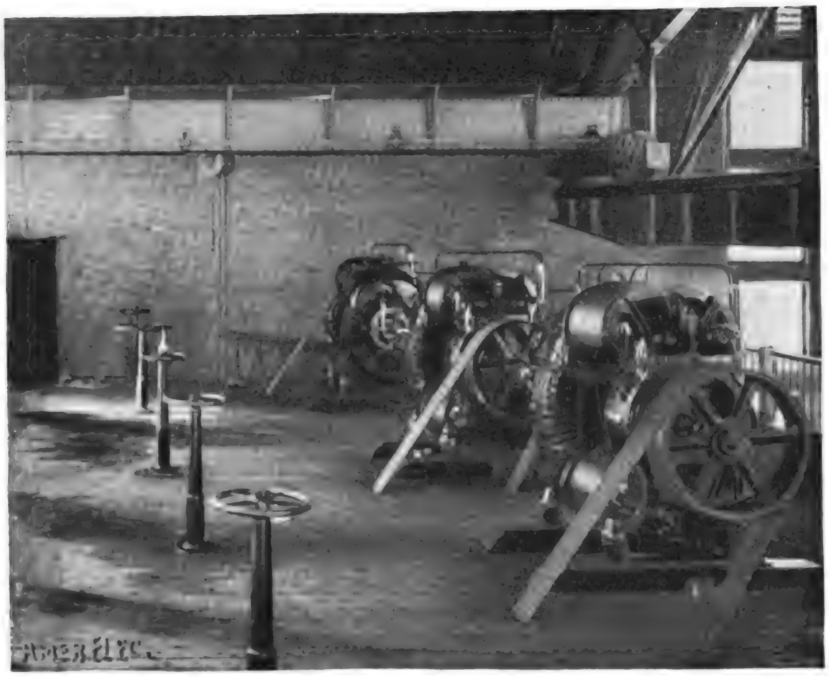


FIG. 5.—SHOWING ROPE DRIVES.

The gymnasium, natatorium, barns and other buildings in the parks are lighted by incandescent lamps with current derived from the alternating mains. The transformers for reducing the potential from 2000 to 100 volts are located in manholes outside the buildings in which the lamps are used, and are oil-insulated. The buildings are wired with interior conduit of the plain iron tube type.

When the station was first started, some months ago, there was noticed a peculiar phenomenon, which stands perhaps alone in the history of commercial arc lighting. A number of lamps were at all times giving out a loud whistling noise, which could be heard at a distance of two blocks or more. The lamps would only give this noise when the arc was long, and stop as soon as the carbon fed, the noise thus traveling from lamp to lamp. At the same time a strong inductive effect was noticed in the telephone and fire-alarm circuits which rendered the whole of these circuits, covering the same territory as the arc circuits, inoperative.

A thorough search for the cause of the trouble was at once instigated by the telephone people, and the invisible effect was subsequently found to be due to electrostatic induction. The test consisted in placing exploring coils, with a telephone as detecting instrument, in different positions with regard to the arc circuit. It is well known that there can be no electromagnetic induction between a rectilinear conductor and a coil or loop at right angles to it, so that if an electric disturbance is observed in the coil when a current flows in the conductor, it must be due to electrostatic induction, provided that there is no leakage between the conductor and coil. Geisler and Crookes tubes were used to determine the distribution of potential in the lead armor of the cables.

The direct cause of the inductive disturbance in the present case was found to be the following: It has been pointed out above that two circuits are run on each boulevard, and that whenever connection is made to a lamp, the mains are connected to a switch in the lower part of the pole, from where armorless cables run up to the lamp. The lead armor of the cables is thus divided into a large nnmber of sections not in contact with each other. The potential of each section depends upon the potential of the conductor at that place, and as there are two circuits on each boulevard, it happens that sections of a large difference of potential are relatively near to each other, thereby causing an inductive effect.

All sections of lead armor were metallically connected, and since then no more trouble of this nature has been experienced.

Electrical Engineering at Lehigh University.

A recent circular of Lehigh University is devoted to the course in electrical engineering at that institution, which is in charge of Prof. Alexander Macfarlane. A number of illustrations give views of the different departments of the electrical laboratory, showing these to be well equipped. The course is classed under the heads of principles of electricity and magnetism, electrical measurements, electromagnets, theory of dynamo-electric machinery, dynamo laboratory, dynamo design, and the technical applications of electricity. Among the practical features of the course we note that each student is required to draw a complete set of plans for wiring some of the University buildings, and a drawing is required of a multipolar generator in all its details, both mechanical and electrical.

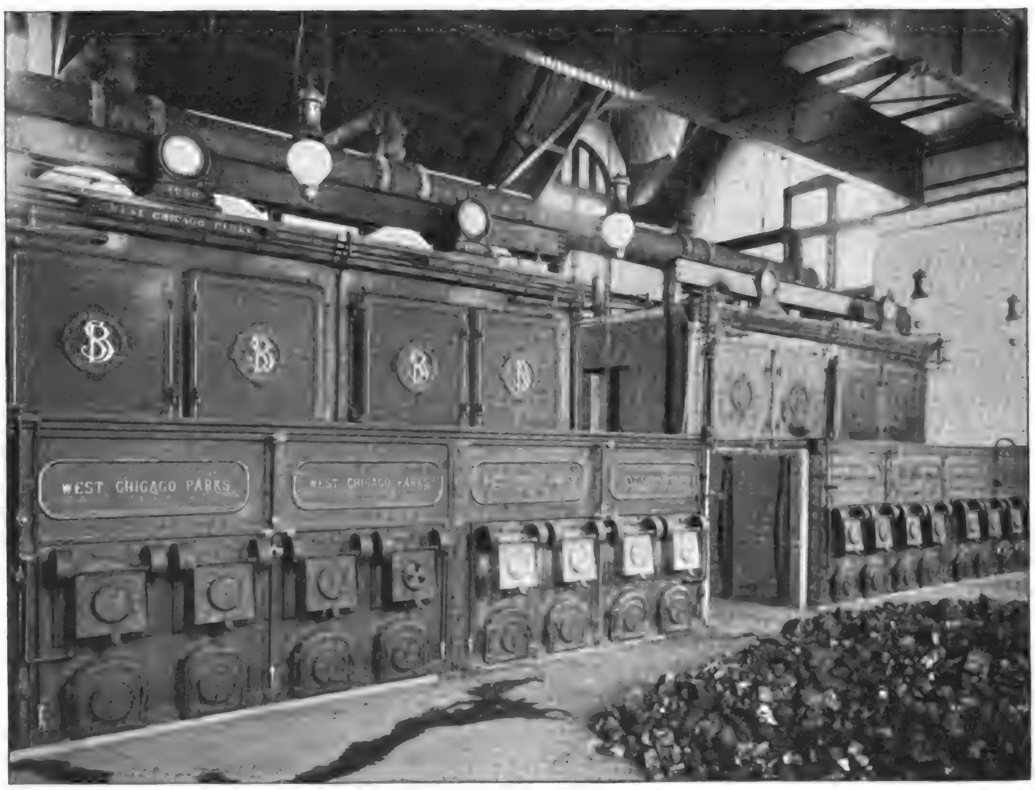


FIG. 6.—BOILER ROOM.

THE INSULATION OF ARMATURE CORES.

BY LOUIS ILLMER, JR.

The prime requirement for a good dynamo is reliability. This property is best acquired by using sufficient insulation. Modern generators are insulated very heavily and it is for this reason that they possess so many virtues.

Street railway motors are now insulated with mica ⅛ in. thick, and yet we find that 500 volts often indirectly puncture this insulation. It has lately been proven that all insulating material is faulty.

Good insulation should withstand high temperatures; it must be mechanically strong; it should not readily absorb vapor, gas or liquid; it must be comparatively cheap and, of course, must be easily applicable.

Mica, asbestos and linen prove best for armature work. Mica is an excellent insulator, but some difficulty is experienced in applying it; the absorption of moisture by asbestos is the most serious fault of that material; cloth chars easily and for this reason can not compete with the above mentioned insulators. Nevertheless by proper use of these materials a very high resistance can be obtained, which will fulfill all practical requirements.

The amount of insulation to be used must be determined by the voltage. Thick insulation often decreases the efficiency, but modern practice grants that this allowance is essential. I shall give a brief description of a well insulated 500-volt street railway armature, and the thickness of insulation for other voltages should be proportional to this.

It is of utmost importance to remember, that the weakest point of the insulation determines its strength, and it is with this thought in view that the resistance of an armature should be estimated.

Insulation is generally stuck to the core by means of shellac, varnish or other compounds. Shellac gives good results, and the best manner of using it is as follows: Dissolve some pure shellac with the least amount of alcohol possible; then heat the compound to the boiling point, and use with a brush while hot. The heating greatly improves the solution, for it expels the air and water present, saturates the compound, and when cool it rapidly solidifies.

Every core that is to be insulated must necessarily be mechanically well constructed, and should be provided with good lamination. All sharp points must be removed so as to avoid all possibility of puncturing the insulation. Owing to the variety in design of armature cores, I will consider each of the following types separately: First, slotless drum armatures; second, slotless ring armatures, third, slotted armatures; fourth, toothed armatures.

The slotless drum armatures are generally provided with narrow grooves in which

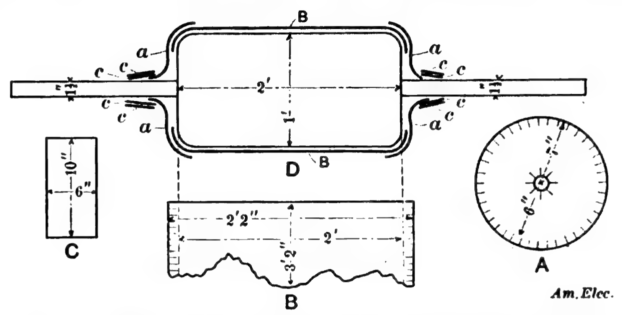


FIG. 1.—INSULATION OF SMOOTH-CORE DRUM ARMATURE.

to insert driving horns; these slots must be thoroughly cleaned before insulating. For the insulation of a 500-volt armature the best clear amber mica should be procured. This is split into thin sheets of about the thickness of ordinary writing paper, and then glued to the core. The pieces of mica should well overlap each other so as eventually to form practically one homogeneous

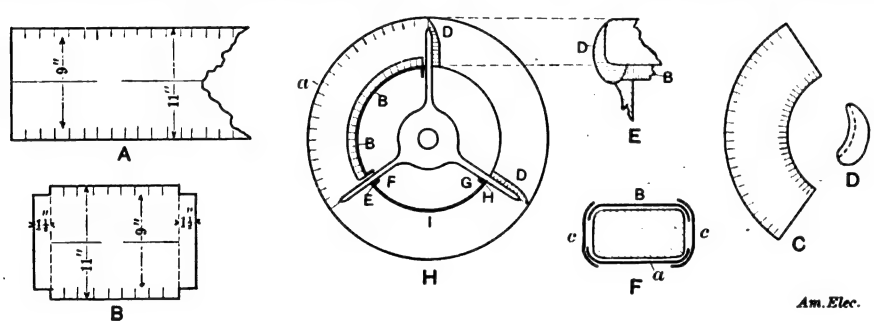


FIG. 2.—INSULATION OF SMOOTH-CORE RING ARMATURE.

piece of mica, $\frac{1}{64}$ in. in thickness, surrounding the entire core.

It is customary to increase slightly the thickness of the insulation at the edges, so as to avoid every possible short circuit or ground.

The core should now receive a good coat of shellac and be left to dry. In the meantime the material for the second coat, consisting of asbestos, should be procured. The asbes-

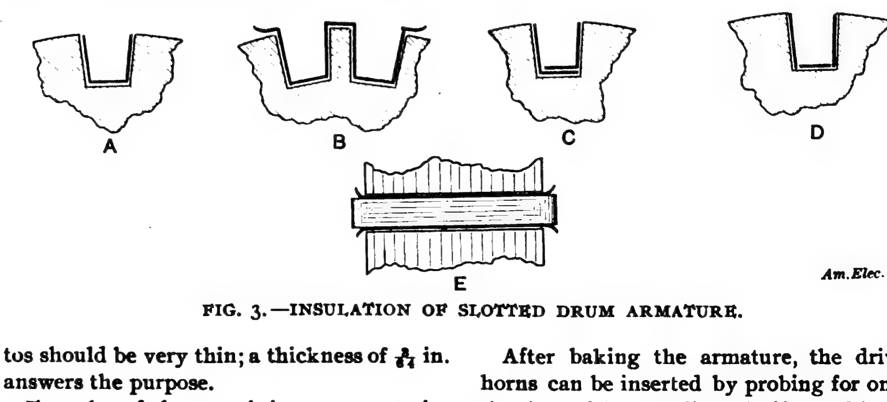


FIG. 3.—INSULATION OF SLOTTED DRUM ARMATURE.

tos should be very thin; a thickness of $\frac{1}{64}$ in. answers the purpose.

For sake of clearness it is necessary to introduce measurements; we shall consider the armature to be 2 ft. long and 1 ft. in diameter.

Measuring the circumference of the armature, we shall find it to be very nearly 3 ft. 1¾ ins. (3.1416 ft.); adding ¼ in. to allow for lap, we obtain about 3 ft. 2 ins. for the length of the piece (Fig. 1—*B*) covering the cylindrical portion of the armature. The amount allowed for lap must be tapered so as to produce a piece of uniform thickness; in fact all tapering should be treated in this manner.

The width of the piece of asbestos (Fig. 1—*B*) should be equivalent to the length of the armature core, plus 2 ins., an allowance made to insulate the edges properly. This piece is then glued to the core as shown by Fig. 1—*D*, indicated by *B*. It will now be necessary to prepare the circular pieces, illustrated by Fig. 1—*A*, which have a diameter of 1 ft. and 2 ins., allowing again a fringe of 1 in. to be inserted to increase the insulation at the edges. Fig. 1—*D* shows the relative position of these various parts when glued in place.

It now remains to insulate the shaft; this is accomplished by cutting a piece of asbestos (Fig. 1—*C*) long enough to make two convolutions about the shaft; the width of this piece can be determined by the collar or other indication obtained by an examination of each core.

Having now completed the second coat of insulation we proceed with the third, consisting of linen cloth (natural color), which is applied exactly in the same manner as the asbestos. The fourth, and last, covering consists of heavy white paper, thus causing an additional increase in the resistance and affording a smooth surface.

We have now an insulation consisting of four different materials. It is in this manner that the highest resistance can be maintained in a practical machine, subject to many different conditions, because the weakness of one substance is equalized by the virtues of the other.

As a rule, the construction of an armature allows the use of sufficient insulation at the corners, but in some designs the lapping of insulation affects the clearance; it is, therefore, necessary to caliper the armature core to ascertain whether sufficient taper has been allowed for the increase of size. The taperless armatures are usually provided with fibre rings at the ends, which serve as insulators.

After the armature has been completely insulated, it should be thoroughly dried, for otherwise the resistance is exceedingly low, owing to the pressure of water and alcohol.

After baking the armature, the driving horns can be inserted by probing for one of the slots with a small penknife; and by employing a pair of dividers the remaining slots can be easily found. The pegs should

be constructed from good straight-grained hickory, because the drag, tending to hold the wire stationary, is very great, and therefore, the pegs must be strong. When fibre is used for this purpose, it often becomes charred, thus loosening the wires from the core and causing unavoidable destruction of the armature. Fibre rings on the ends of a core often lead to the same trouble.

We will now consider the slotless ring armature, which is represented by Fig. 2. Owing to the spider of these armatures, there is often considerable difficulty experienced in insulating them. The suggestions given for the drum armature must also be observed here. The circumference is insulated first; ¼ in. is again allowed for lap; the width of this piece of insulation (Fig. 2

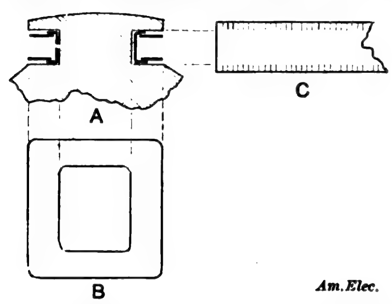


FIG. 4.—INSULATION OF TOOTHED ARMATURE.

—A) is equal to the length of the cores plus 2 ins. allowed, as before, for the insulating of the edges.

To insulate the inner surface of this core it is necessary to prepare three pieces of material (Fig. 2—B), having the same width as the piece insulating the outer surface, and the length being ascertained by finding the distance between the spider, measured by the arc EIH (Fig. 2—H) and adding to this the value of the equal pieces *E F* and *G H*, which partly insulate the spider. *G H* is generally equivalent to 2 ins. in a medium-sized armature, and varies accordingly.

These pieces of insulation are then glued in place, as shown by Fig. 2—H, indicated by *B*. We next prepare three ring-shaped segments as shown by Fig. 2—C, again allowing the required margin to insulate the edges ef the core thoroughly. Lastly, it is necessary to cut several pieces similar to Fig. 2—D, which finish the insulating of the spiders, as shown by Fig. 2—H and indicated by *D*. This completes the first coat of insulation. If necessary, another can be added by repeating the same process.

Little difficulty is experienced in insulating a slotted drum armature; the simplest manner is to employ cloth or other flexible insulation, and glue same to the iron core, as illustrated by Fig. 3—A. One serious difficulty is found in adopting this style of insulation, because the cloth does not stick tightly to the iron core; it therefore causes much annoyance to the winder, and occasionally allows the poorly insulated wire to touch the core. To avoid these obstacles it is often nccessary to insulate the slots with one continuous piece of cloth, as shown in Fig. 3—B. After the winding is completed, the superfluous cloth is easily removed, thus insuring uniform insulation upon the core. Pounding devices of any kind should be used very little, for otherwise the sharp corners of the iron will puncture the insulation.

When mica is used to insulate the grooves of a slotted armature, two general methods, besides the first one mentioned, can be employed. The first, shown by Fig 3—C, is practical when the insulation is not very thick. The width of the mica used for this purpose should be equal to the width of the slot plus its depth; this piece is then bent at right angles and glued in place, as illustrated. The length of this piece of mica, as well as for all other insulation of this style of armature, varies as the length of the core, and to this must be added a small allowance to insulate the corners, as shown by Fig. 3—E. For heavier insulating, the method illustrated by Fig. 3—D is the most serviceable. Two separate pieces of mica insulate the sides of the slots, and the bottom is insulated by a third piece, wedged between the first two. This style of insulation gives the best satisfaction, but can only be employed when the mica is of considerable thickness.

As the slotted ring armature is insulated in the same manner as the slotted drum, it is unnecessary to consider each separately.

We have yet another type of core which deserves consideration; that is, the toothed armature, illustrated by Fig. 4.

To insulate a tooth of this style of armature core, it is necessary to prepare one fringed piece of insulation (Fig. 4—C) which protects the bottom of the tooth as shown by Fig. 4—A. We next cut two pieces similar to Fig. 4—B, which insulate the sides. By cutting this piece at the dotted line (Fig. 4—B), the same can be slipped over the tooth and glued in place.

We have now briefly considered the manner in which the general types of armatures are insulated, and by following the suggestions herein contained, it is a comparatively easy task to insulate the many combinations of designs of cores now upon the market. But we must keep clearly in mind that upon this insulation depends greatly the reliability of the dynamo; therefore neatness and exactness must at all times be practiced.

A Reporter on Ohm's Law.

A reporter of the Boston *Herald*, in an account of a lecture by Prof. Trowbridge on some recent work with the electric spark, considers that some of the experiments related reverse Ohm's law, which law, he states, asserts that "the resistance which a current overcomes is proportionate to the distance traversed." The grounds upon which this opinion is based are that "a flash of lightning traveling through 2 miles of air meets with no more resistance than a flash traveling through 2 ft." The reporter also praises Prof. Trowbridge for demonstrating why lightning goes down heated chimneys —a fact which, he declares, has long puzzled scientists, for the reason that "hot air affords greater resistance to electricity than cold air."

ELECTRIC FAN MOTORS.

MODELS OF 1897.

At the present day the electric fan has become one of the necessities of the summer season wherever there is an electric supply service, being no longer regarded as in any sense a luxury. In its first days looked upon as little more than a curiosity and employed rather for advertising purposes than for utility, it gradually entered into wider use, but for a long while was considered in the light of a luxury. At the present day, however, the cost of operation is considered in the same light as that of other indispensable modern conveniences, and the electric fan has been permanently added to the equipment of offices, while its use in private residences is rapidly extending.

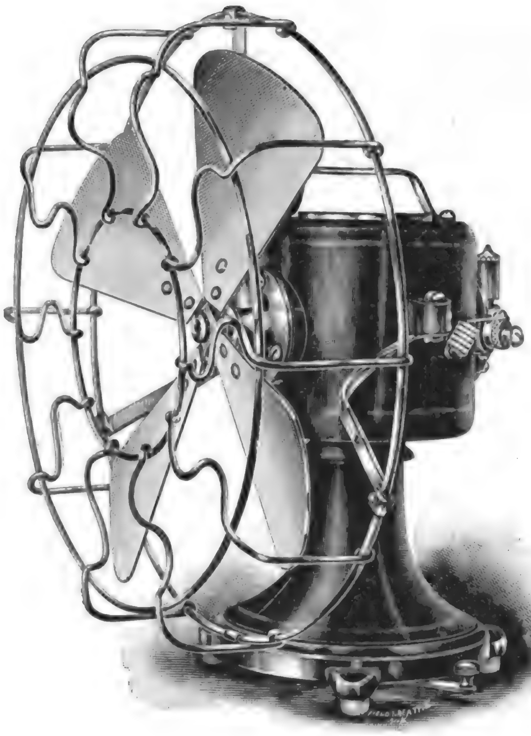


FIG. 1.—PARAGON.

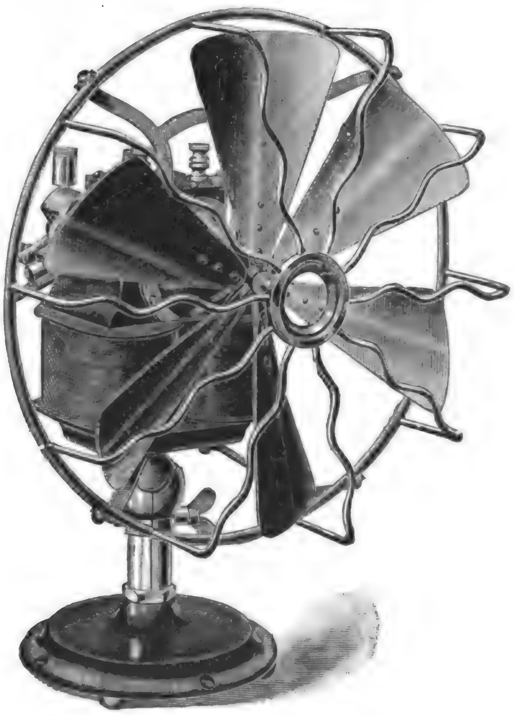


FIG. 2.—ELECTRIC APPLIANCE CO.

The greatest extension of use has occurred during the past several years, being coincident with the great improvement which the efficiency of the motor has undergone. In the earlier days 10 or 15 per cent. was perhaps the usual efficiency, and this doubtless had much to do with the slow progress then made. Now such motors are designed after the same scientific principles as the largest machines, and their efficiency is usually above 50 per cent.

FIG. 3.—GOLDMARK & WALLACE.

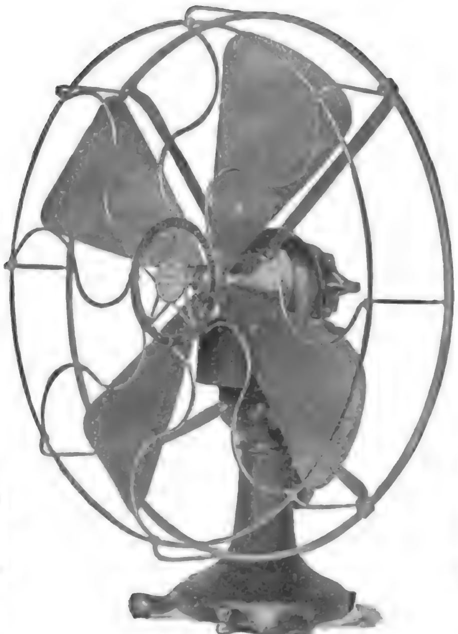


FIG. 4.—WESTERN ELECTRIC.

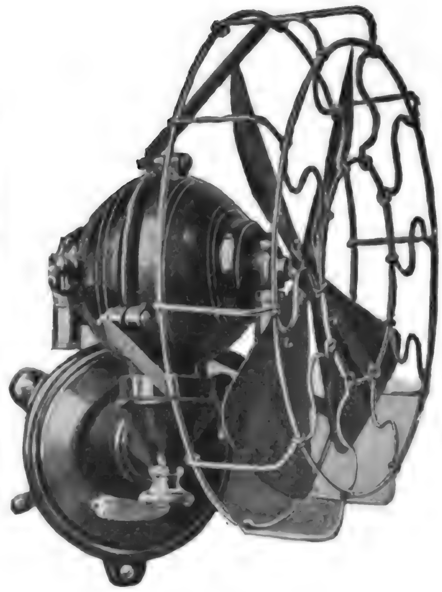


FIG. 5.—LUNDELL.

The accompanying illustrations form almost a complete exhibit of the electric fans that will be offered to the prospective users during the coming season, and are of three different types—for use with a battery, with continuous lighting currents or with alternating currents. In some cases a manufacturer puts forth both the latter types, and some make fans for both direct-current lighting circuits and batteries; usually, however, the latter form a specialty, the makers also supplying the batteries from which they are run.

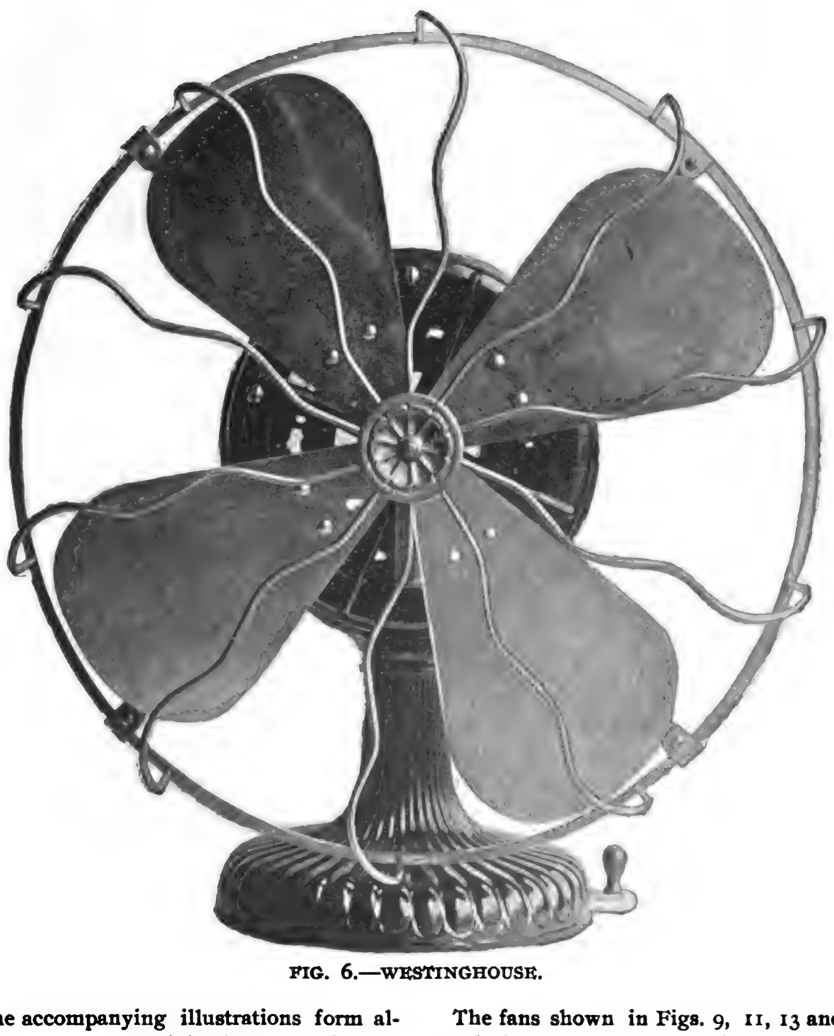


FIG. 6.—WESTINGHOUSE.

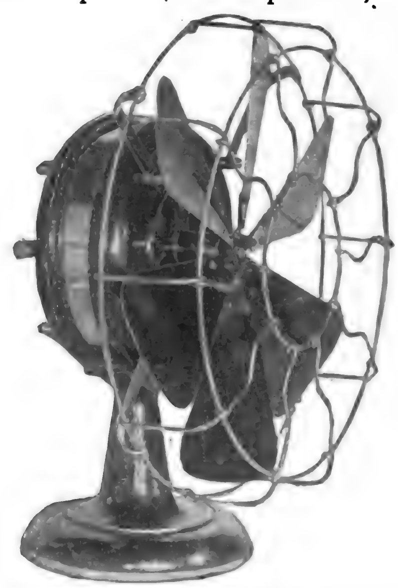


FIG. 7.—GENERAL ELECTRIC, DIRECT CURRENT.

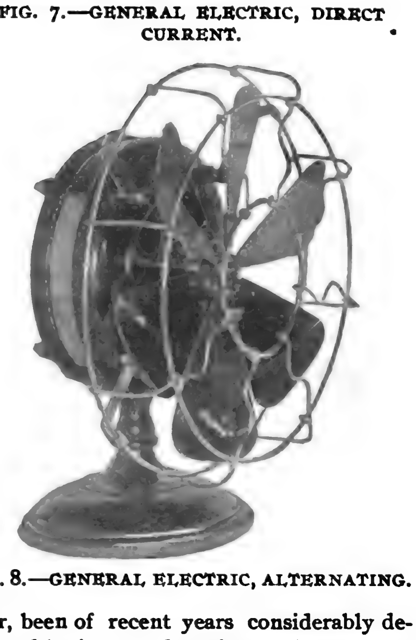


FIG. 8.—GENERAL ELECTRIC, ALTERNATING.

The fans shown in Figs. 9, 11, 13 and 20 are designed to run from primary batteries, and therefore have a much wider field than the other types named. This advantage is somewhat handicapped by the greater expense of operation, which expense has, however, been of recent years considerably decreased by increased efficiency of the motors

and the development of batteries specially adapted to the purpose for which they are used. The fans are also of smaller size than those run from lighting circuits, and for use in small offices, dining rooms, sick rooms, physicians' operating rooms, dental parlors and similar places, the item of cost does not become a serious one. As an example of the small quantity of electrical energy required, the 9-in. fan shown in Fig. 20 will run at 1360 revolutions per minute on 2 amperes of current at less than 3 volts, equivalent to considerably less than a hundredth of a horse power.

FIG. 9.—ARMATURE BELL CO.

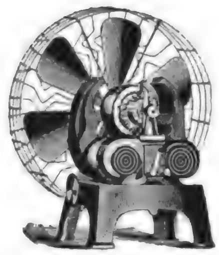


FIG. 10.—CHICAGO ARMATURE CO.


FIG. 12.—HUNTER.

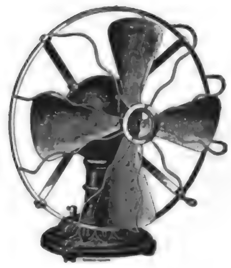


FIG. 11.—BOSTON MOTOR CO.

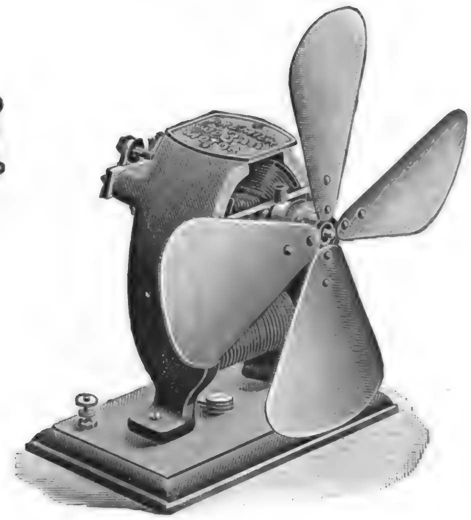


FIG. 13.—RODRIGUES.

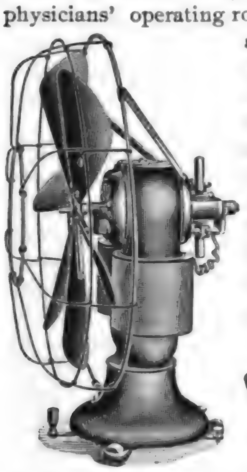


FIG. 14.—ROTH.

Figs. 6 and 8 illustrate alternating-current fan motors. These types have the advantage that the speed can be regulated at will and with practically no loss of energy. This is accomplished by means of a reactive coil, which enables a counter E. M. F. reacting on the impressed E. M. F., to be introduced into circuit. Both fans are made for the two frequencies in current use. The fields of both are built of thin soft-iron punchings having inwardly-projecting pole-pieces carrying the field coils. The armature of the former is laminated, being constructed of steel disks slotted to receive the conductors; that of the latter is a laminated core through which, near the periphery, are run bare copper rods riveted to copper disks at each end of the core.

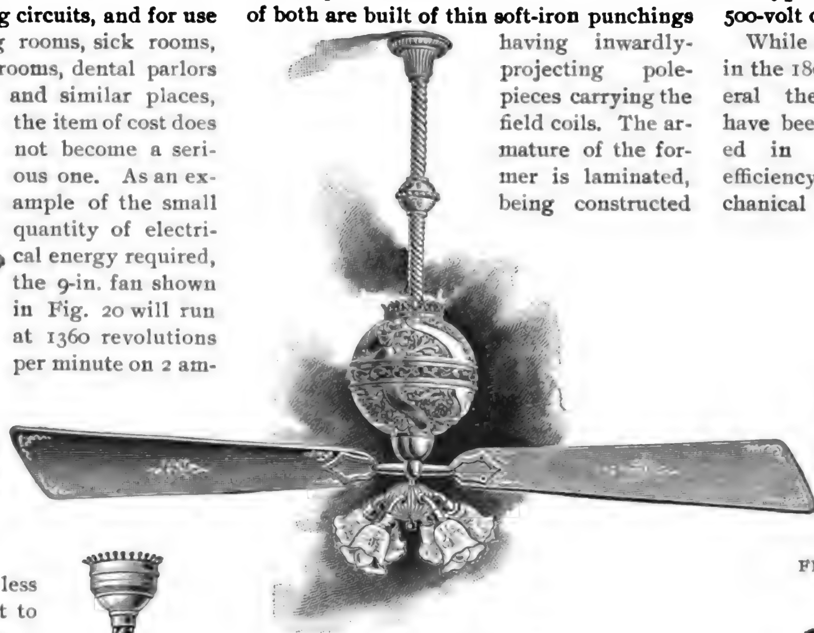


FIG. 6.—BACKUS.

The remaining illustrations are of fan motors for direct-current lighting circuits, and voltages corresponding to the several in ordinary use for incandescent lighting, though some of the larger sizes of several of the types shown are also wound for 220 and 500-volt circuits.

While no striking changes are to be noted in the 1897 over last year's models, in general the motors have been improved in electrical efficiency, the mechanical details have been made more perfect and the styles are more differentiated. A ceiling fan no longer consists merely of a small motor concealed in a gas or electric fixture finishing with-

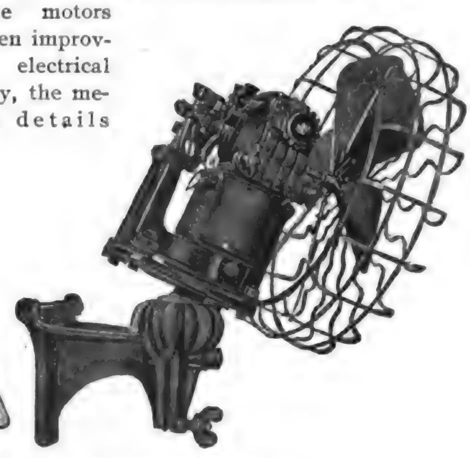


FIG. 15.—CROCKER-WHEELER.

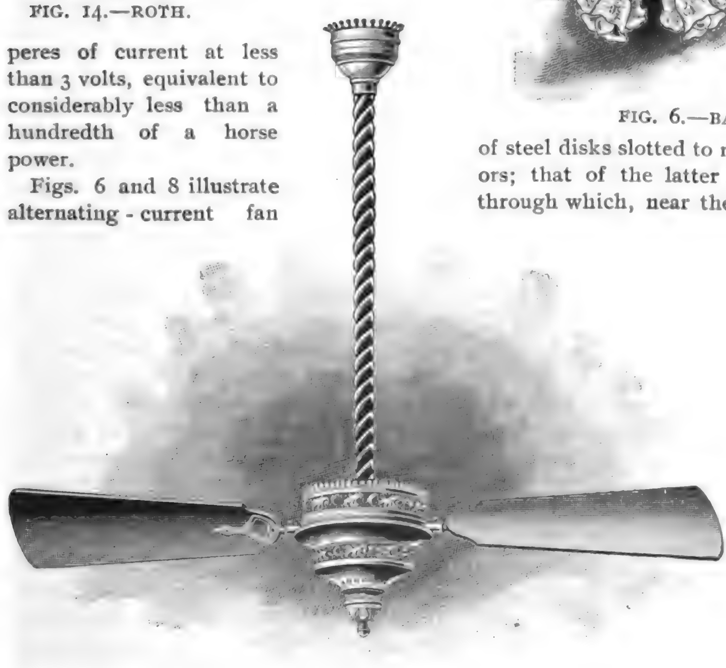


FIG. 17.—DIEHL.

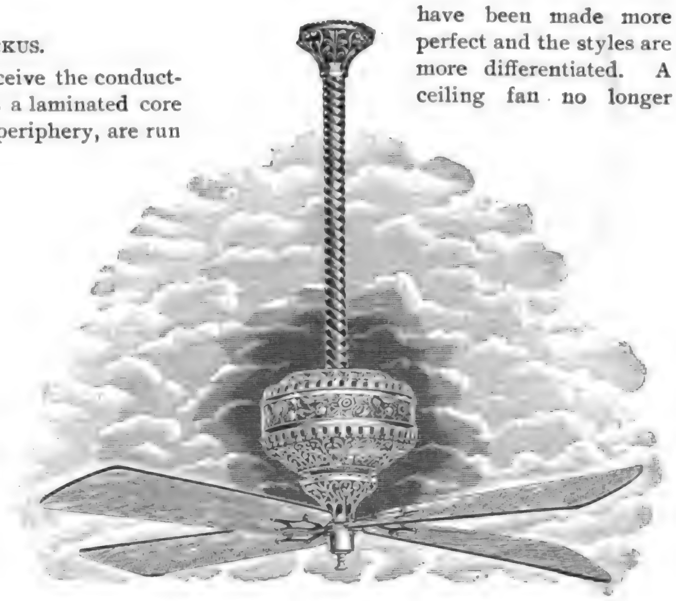


FIG. 18.—BATES.

out regard to the proportion of parts, but is designed to present an artistic effect as a whole. Wall fans are constructed to look as if made for the position they are to assume, in most cases the motors being supplied with an adjustable bracket, enabling the fan so be so turned as to direct its current of air in any desired direction. The standard types for desks and tables have also, as a rule, been given an appearance less that of a machine and more in harmony with the surroundings.

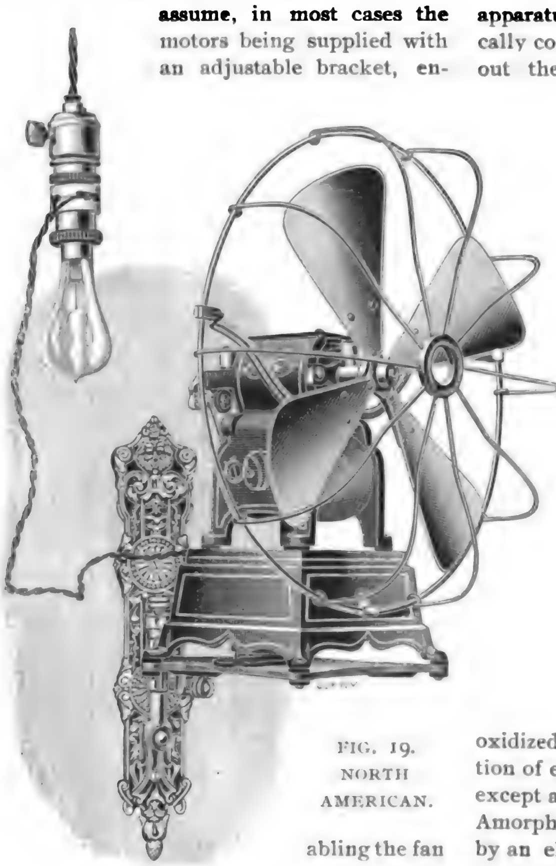


FIG. 19. NORTH AMERICAN.

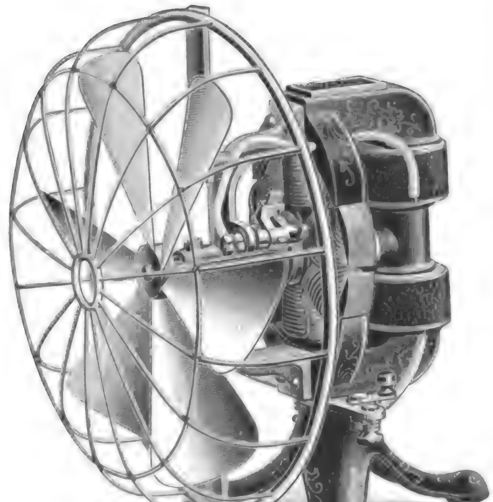


FIG. 20.—EDISON.

In conclusion, it may be added that one of the economical advantages of the electric fan is the high speed at which it runs. Many years ago elaborate experiments were conducted in England on the relation between the speed and efficiency of power fans, and it was found that the efficiency increased continuously up to the highest speeds tested. At low speeds the efficiency was found to rarely equal ten per cent., but at the highest speeds this increased to 30 per cent. and even beyond.

THERMO-ELECTRIC BATTERIES.

BY C. J. REED.

The thermo-electric battery is the only apparatus by which heat has been practically converted into electrical energy without the use of a heat engine. It has been shown by Thomson and Houston and others that heat may be converted into electrical energy by applying it to a magnet to alter the magnetic permeability, but the few attempts that have been made to reduce this method to practice have been unsuccessful.

Many attempts have been made, particularly within the last ten years, to obtain electrical energy directly from the oxidation of carbon, either with or without the aid of heat. Notwithstanding all that has been recently written by numerous claimants to the contrary, and notwithstanding the very many alleged processes recently discovered for obtaining "electricity from carbon without heat," the fact remains that carbon has never yet been oxidized without the continuous application of external heat, or of electrical energy, except at or above its igniting temperature. Amorphous carbon may be slowly oxidized by an electric current when it is used as an anode in the electrolysis of an aqueous electrolyte, and graphite may, by repeatedly heating it with powerful oxidizing agents, be slowly converted into graphitic acid $(C_{11} H_4 O_5)$, which still contains 85 per cent. of the original energy of the carbon. In both these cases, however, the oxidation, instead of evolving energy, requires the expenditure of a large amount of energy of a very expensive form, in the one case, electrical energy being consumed, instead of being produced. No researches capable of verification have yet been published which give any indication or proof that carbon has ever been oxidized at low temperatures, except as above stated. Nor is there any reason to believe that in those cases its oxidation has resulted in the evolution of as much energy as that which was expended in causing the oxidation.

The conversion of heat into electrical energy by the thermo-electric battery is direct, and for certain purposes would be very convenient, were it not for the great expense of the apparatus and its low efficiency and capacity. The great convenience of this form of electric generator would in many cases outweigh these objections, especially in cases where the amount of electrical energy needed is very small. In such cases the efficiency is of no importance whatever.

A thermo-electric battery consists essentially of two dissimilar electric conductors in contact at one point, the point of contact or "junction" being either heated above or cooled below the temperature of the poles or points on the conductors from which electric current is taken. Like galvanic batteries and other electric generators, thermo-electric batteries may be connected together in series to give a high electromotive force or in multiple for low internal resistance. Thermo-electric batteries or junctions may be divided into two general classes.

1. Thermo-electric batteries not containing electrolytes, or those in which no chemical action takes place. These consist of two conductors in electrical contact, neither of which is capable of electrolytic decomposition. Such conductors are either chemical elements, usually metals, or metallic alloys.

2. Thermo-electric batteries containing an electrolyte, or those in which the passage of an electric current causes electrolysis or chemical action. In batteries of this class one of the two conductors is an electrolyte.

There is a great difference, both practical and theoretical, in the behavior of these two kinds of thermo-electric junctions. So great is this difference that those belonging to the second class have been frequently mistaken for galvanic batteries.

The practical difference between the two classes is that those of the first class, when properly constructed and not subjected to very high temperatures, are permanent and indestructible and have a very low thermo-electric power, generally only a few millionths of a volt for each degree of difference in temperance between the hot and cold junctions. They are necessarily also of very low efficiency. The ordinary antimony-bismuth thermopile is a familiar example of this class.

Thermo-electric junctions of the second class are not permanent, but undergo necessary chemical changes when in action, the amount of the chemical change being proportional to the current produced. This necessitates not only the application of heat to the hot junction, but also the frequent renewal or regeneration of such parts as undergo permanent chemical change, in the same manner as an ordinary primary battery requires the renewal of zinc and oxidizing chemicals. The thermo-electric power of junctions of this class is very great, being generally several hundred or thousand times that of junctions belonging to the first class. The possible efficiency of junctions of the second class is comparatively very high, both on account of the high thermo-electric power and the fact that the chemical or electrolytic reactions may be used to advantage to oxidize fuel within the thermo-electric circuit, its energy being added to the circuit.

The battery recently described as the Jacques "carbon-consuming primary battery" belongs to this class, and gives, according to Dr. Jacques, and others who have previously used it, an efficiency of about 32 per cent. The so-called "heat cells" of Becquerel and Jablochkoff, in which a carbon rod and a metal are heated in contact with a fused alkaline salt, belong to this class; also the "thermo-chemical" cells of Pacinotti and others, in which an aqueous saline solution in contact with two conducting electrodes, is heated at its point of contact with one of the electrodes.

Fig. 1 illustrates a simple form of thermo-electric junction belonging to the first class, A and B representing bars of two different metals, such as antimony and bismuth, either soldered or otherwise fastened together at J.

The junction, *J*, is heated above the temperature of the poles or terminals, *P* and *P'*. Innumerable forms of thermopiles constructed of two metals, differing in the shape of the parts and manner of grouping them together, have been patented. But none of them have come into very extensive use, the most important being the antimony-bismuth thermopile, used for measuring differences in temperature. Alternate pieces of chilled and unchilled iron have also been used instead of dissimilar metals in building up a thermopile.

Fig. 2 shows the heat cell of Archereau and Jacques, belonging to the second class.

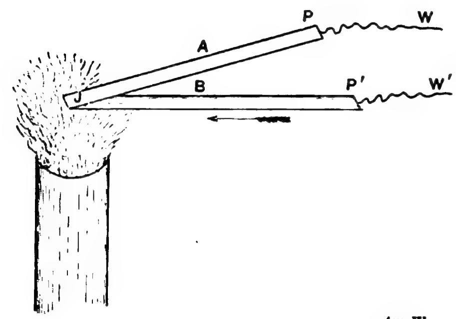


FIG. 1.—SIMPLE FORM OF THERMO-ELECTRIC CELL.

P represents a conducting vessel, preferably of iron, having a conducting wire, *W*, attached, and containing fused caustic soda or caustic potash. The vessel is heated by an external source of heat to about 400 degs. or 500 degs. C. Into the fused caustic is placed a carbon rod, *C*, provided with a conducting wire, *W'*. *T* is an air-tube dipping into the fused alkali and terminating in a distributor, *R*, through which air is blown.

Great claims have been made for the efficiency of this cell, but its commercial utility will depend more on the labor and cost of renewing the electrolyte, carbon and iron pots, and upon the convenience and adaptability of the apparatus, than upon its efficiency. No results have been obtained to warrant the belief that this or other thermo-electric batteries containing electrolytes will ever be preferred in practice to those of the first class. In this connection we may remark that it is possible to build heat engines giving an efficiency even greater than 35 per cent. and that some gas engines in practical operation to-day are giving nearly that efficiency. Yet in nine cases out of ten a steam engine and boiler, giving only from 5 to 10 per cent. efficiency is preferred in practice. This shows that other considerations than the efficiency are generally the determining factors in the selection of a power generator.

Fig. 3 shows a thermo-chemical cell, consisting of two bent copper tubes dipping into an aqueous solution of a copper salt, such as copper nitrate. Through one tube a current of steam is forced and through the other a current of cold water. Zinc tubes and a zinc salt may be substituted for the copper tubes and copper salt, or tubes of any soluble metal in contact with a salt of the same metal may be used. A cell of this kind having zinc tubes in a solution of zinc nitrate is said to give about one volt.

Two pieces of metal separated by a thin film of conducting metallic oxide give a high electromotive force when the two pieces of metal are maintained at different temperatures. Two pieces of copper separated by a thin film of copper oxide (formed by heating the copper in the air until it becomes of a dark bluish-black color) give an electromotive force of .4 volt when one side of the junction is maintained at a red heat. But the electrolytic action on closed circuit soon destroys the continuity of the intervening film and interrupts the action of the couple.

Among the peculiar thermo-electric cells containing electrolytes, which have been erroneously supposed to be galvanic batteries, is the "tin-chromic-chloride cell," recently exhibited, and patented eleven years ago, by Mr. Willard E. Case. In this cell a chemical action takes place on the application of heat, which spontaneously reverses

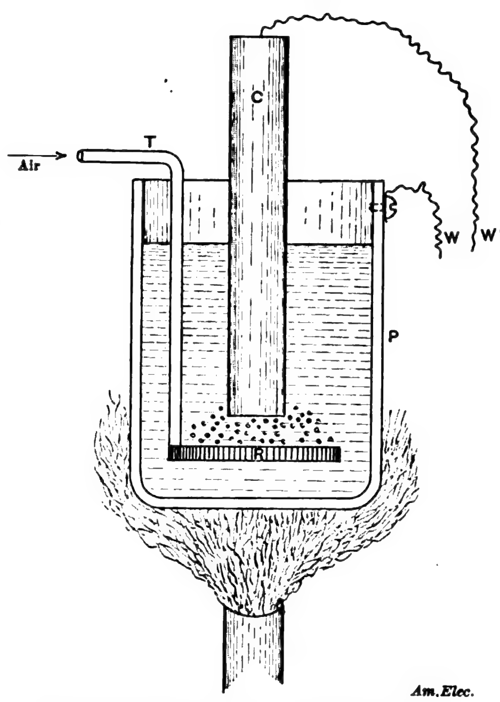


FIG. 2.—ARCHEREAU-JACQUES TYPE OF HEAT CELL.

on cooling. The energy concerned in these chemical reactions has no part whatever in the production of the electric energy. Any chemical reaction, which evolves energy, must on reversing absorb the same amount of energy; and any chemical reaction that absorbs energy, must on reversing evolve the same amount of energy.

In the Case cell the electric current is produced at the higher temperature. The chemical change which takes place at this temperature is caused by the absorption of heat, that is, the reaction is endothermic and cannot be evolving energy. At a lower temperature the reaction spontaneously reverses and evolves as heat the energy which was absorbed at the higher temperature. But while this spontaneous reaction is taking place no electric current is produced. The supposition that the chemical action in this cell contributes in any way to the production of the electrical energy involves the admission that an isolated body of matter is capable of absorbing external heat at a low temperature and evolving it without loss at a higher temperature. Such a transformation is known to be impossible, being equivalent to an inexhaustible source of power or the so-called "perpetual motion." The only useful function this chemical reaction could perform would be, as in all other thermo-chemical cells, to act as an electrolytic vehicle, which enables the electric current to pass through the cell without producing "polarization" or gas-films.

The development of electrical energy in a thermo-electric battery is due to two peculiar reversible actions of heat upon electric conductors, one known as the Peltier action or effect, and the other, as the Thomson effect.

The Peltier Effect.—If an iron bar, *A* (Fig. 1), and a copper bar, *B*, be soldered or otherwise electrically connected together at *J*, an electric current passing across the junction from copper to iron in the direction indicated by the arrow, absorbs heat from the junction, tending to reduce its temperature. If we apply heat to the junction and raise its temperature the current increases, that is, heating the junction tends to produce or increase a current in the direction of the arrow. On sending a current across the junction in the opposite direction, heat is evolved at the junction, and its temperature rises. Heating the junction will diminish the current in this direction, or cooling it will increase the current. These reversible transformations of heat into electrical and electrical into heat energy are due to the Peltier effect, which includes all reversible thermo-electric effects that take place at the junction only.

The Thomson Effect.—Returning again to Fig. 1, an electric current passing through a copper conductor, *B*, in the

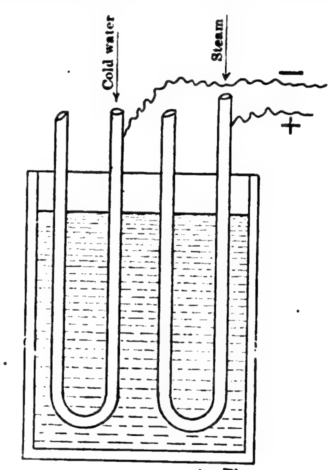


FIG. 3.—THERMO-CHEMICAL CELL.

direction indicated by the arrow, tends to convey or carry heat with it from *P'* towards *J*, while in passing from *J* to *P* in the iron bar the current tends to convey heat backwards towards *J*. The effect in both metals is to accumulate heat at the junction, *J*, and to remove it from *P* and *P'*. Cooling *J* tends to increase, and heating *J* tends to diminish the current. Sending a current in the opposite direction produces the opposite effects. This action is known as the Thomson effect, and includes all reversible thermo-electric effects that take place in an unequally-heated conductor without reference to its junction with other conductors.

It has been found that all metals gener-

ally, with the exception of lead, exhibit the Thomson effect to an appreciable degree, and that the Peltier effect is exhibited by all thermo-electric junctions of two metals, except at certain temperatures (usually at all temperatures except one) called "neutral points," at which the Peltier effect becomes zero.

In any thermo-electric couple the electromotive force for any given temperature of

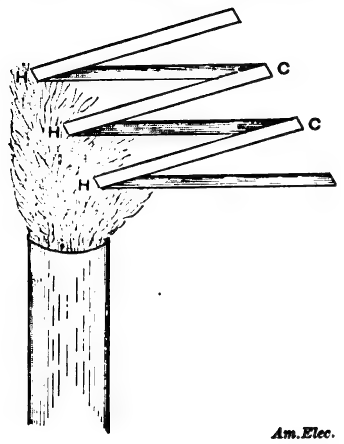


FIG. 4.—METALLIC THERMOPILE.

the hot and cold junctions is the resultant or sum of the Thomson and Peltier effects. It was shown by Thomson (Lord Kelvin) that the coefficient of the Peltier effect depends only upon the current strength, the nature of the materials and the absolute temperature of the junction. Tait has shown, on the supposition that the coefficient of the Thomson effect is also proportional to the absolute temperature, the relation between these effects and the resultant electromotive force, in what is known as the thermo-electric diagram. He found that the curve of thermo-electric power of a metal is generally a straight line.

Considering the efficiency of a metallic thermo-electric battery, we find it necessarily very small—not so much from theoretical limitations as from the imperfections of the materials found in nature. We may easily construct thermo-electric junctions having a working range of temperature between 20 degs. C. and 1000 degs. C, which would allow a theoretical possibility of obtaining about 80 per cent. But in practice we find that the substances which might stand these extreme temperatures are otherwise impracticable and inefficient, chiefly because the best electric conductors generally exhibit the lowest thermo-electric power and entail the greatest losses of heat by conduction.

In Fig. 4, *H* represents metallic junctions, which are kept at a high temperature, and *C* the alternate junctions, kept at a low temperature. It is well known that if a bar of metal be heated at one end and cooled at the other, heat will pass rapidly by conduction from the hot to the cold end. All heat that passes in this manner from *H* to *C*, in a thermopile is entirely wasted, not taking any part whatever in the production of electric current. The same is true of all heat lost by radiation from the surface of the bars between *H* and *C*. In practice these two losses amount to nearly all of the heat received at *H*, and the total heat actually received at *H*, is generally not over 50 per cent. of what is actually produced by the combustion. We may increase the electromotive force by increasing the difference of temperature between *H* and *C*. But the rate at which heat is lost by conduction along the bar from *H* to *C*, increases in proportion to the difference in temperature, so that, while we increase the capacity of metallic junctions by increasing the difference of temperature, we diminish their efficiency, supposing other conditions to remain the same. This loss would not be so great in non-metallic junctions, in which the thermo-electric power is comparatively high and the thermal conductivity comparatively very low.

On account of the loss of heat by conduction and radiation, the capacities of similar metallic thermopiles of different sizes, instead of being proportional to the fourth or fifth power of the like dimensions, as is the case with dynamos, are not quite proportional to the first power of the like dimensions. In other words, while the capacities of dynamos of similar form increase more rapidly than the weights, the capacities of similar metallic thermopiles are approximately proportional only to the cube roots of the weights.

The efficiency also of metallic thermopiles of a given form, instead of increasing with increased dimensions, appears to decrease rapidly. The logical practical interpretation of this is, that the less we have of thermo-electric battery, that is, the smaller the amount of energy we require from this form of generator, the better off we may consider ourselves. In this respect theory and practice agree, the only practical uses

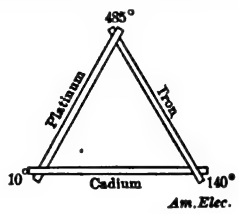


FIG. 5.—CIRCUIT DEVOID OF PELTIER EFFECT.

of thermopiles being those in which the amount of energy transformed is very minute.

In selecting the materials for a thermo-electric battery it is advantageous to get two conductors in which the Thomson effects are in the opposite directions, as in iron and copper, so that the application of heat to alternate junctions tends to produce a current in the same direction in the circuit. The current due to the Thomson effect in both metals should also be in the same direction as that due to the Peltier effect at all temperatures within the working range. This means that the neutral point should be at a low temperature. In this respect an iron-copper couple is at a disadvantage at low temperatures, since the Thomson and Peltier effects oppose each other until a temperature of about 250 degs. C. is reached.

Both conductors should have the greatest possible electric conductivity, in order to oppose the least resistance to the current. They should at the same time have the smallest possible heat conductivity, in order to allow the least loss of heat by conduction from the hot to the cold junction. These two requirements nature has decreed to be incompatible, since substances are generally conductors of heat in proportion to their electric conductivity. Materials should be so chosen, if possible, that the cold junctions may be maintained as nearly as possible at the temperature of the neutral point, to prevent loss of heat at the cold junction by the Peltier effect.

By employing three different metallic conductors joined in series and maintaining the three junctions at their neutral temperatures, a thermo-electric circuit may be obtained, in which there is no Peltier effect. A circuit of this kind, constructed of platinum, iron and cadmium, is shown in Fig. 5. If the platinum-iron junction be maintained at 485 degs. C., the platinum-cadmium junction at 10 degs. C. and the iron-cadmium junction at 140 degs. C., a current will flow through the circuit due solely to the Thomson effect.

Conductors should also be chosen with reference to their state and durability under the required conditions. Solid conductors are more convenient for portability and are less liable to accidental derangement than fused or other liquid conductors. The conductors should be incapable of oxidation or other chemical change under the working conditions. In junctions of the second class chemical changes and liquid conductors seem to be a necessary evil. Solid electrolytes, such as the oxides of copper, would probably be more expensive to renew or regenerate than a liquid electrolyte.

A study of the thermo-electric properties of all bodies heretofore examined gives us little or no reason to hope that this method will ever be preferred for the transformation of energy on a large scale, except through the discovery of new chemical elements having properties radically different from the properties of any known substance. While there is undoubtedly a possibility of such a discovery, the probability is not encouraging.

FOUR-WIRE, THREE-PHASED SECONDARY DISTRIBUTION.

As is well-known, the three-phased system of distribution may be made the equivalent of a six-wire system by running a fourth wire from the neutral point of the windings of the generator or of transformers. Sometimes the three main wires are reserved for power purposes and lamps placed between these three conductors and the neutral.

As shown in previous articles, the size of

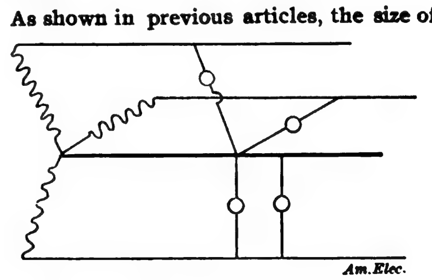


FIG. 1.—UNBALANCED NEUTRAL.

each main wire of a three-phased system may be determined by calculating the size of wire for a continuous-current system, and taking one-half of this for each three-phased wire, allowance in the calculation being made for the increased current due to an inductive load.

As to the size of the neutral wire, the practice is to make it about half the size of that of the other three wires. If, however, the load were perfectly balanced—that is, if there were the same number of lamps in each branch—the size of the neutral wire would theoretically be zero, for it may readily be seen there is then no passage of cur-

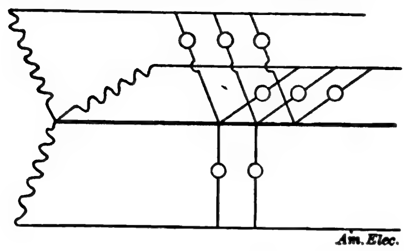


FIG. 2.—UNBALANCED NEUTRAL.

rent at the neutral point of the windings of generator, and consequently none in the neutral wire. The more the unbalancing the larger the size of this wire becomes. If, for instance, between two of the legs and the common wire one lamp is placed (Fig. 1), and between the third and the neutral two lamps, the current in the neutral would correspond to that of one lamp. If three lamps (Fig. 2) were placed between each of two of the legs and two only in the third, a current corresponding to one lamp would again flow in the neutral.

Fig. 3 is a simple diagram which shows how to determine the current in each case. The condition is indicated when one lamp is put between one leg and the neutral, two lamps between the other leg and the neutral, and three lamps between the third and the

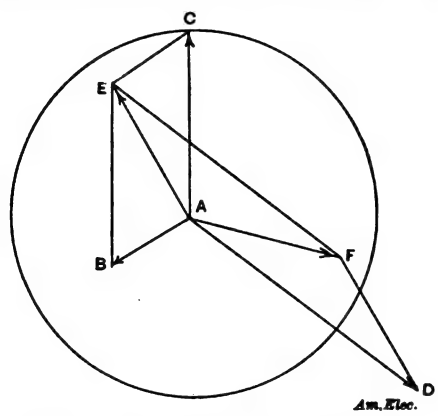


FIG. 3.—DIAGRAM SHOWING CURRENT FLOWING IN NEUTRAL.

neutral. *AB*, *AC* and *AD* are three lines making equal angles with each other, or 120 degs. The length, *AB*, represents, to any scale, the magnitude of the current in one of the lines, *AC* in the other and *AD* in the third. By combining *AB* and *AC* we get *AE*, and the resultant of *AE* and *AD* or *AF*, gives, to the scale chosen, the current in the neutral wire.

AN ELECTRIC RAILWAY EXPEDIENT.

BY "PRACTICAL."

On two occasions in the writer's experience, have the following conditions presented themselves, and on one of these occasions was the method of relief adopted a success. On the other it failed not through any deficiency in the method itself, but rather for want of proper facilities for carrying out the method. The conditions were as follows:

The compound-wound street railway generators running from separate engines and feeding isolated sections of the same trolley service. There was an equalizer between them, but this was used only on special occasions when it was necessary for both machines to work together on any particularly overloaded part of the line. In this case feeders F_1 and F_2 were joined together by means of a separate switch provided for the purpose.

In Fig. 1, *A* and *B* are the respective generators with their shunt and series fields indicated but not lettered. *E* is the common ground wire of the two machines; *K* is the equalizer switch, not used in the present case; *T* is the section of the trolley fed by machine *A*, through feeder *F'*, and *T'* the section fed by *B*, through feeder F_2; K_1 is *A*'s feeder switch, K_2 that of *B*'s feeder.

Lightning struck *A*'s armature and grounded it so as to necessitate its removal to the repair shop. This threw the entire load on *B*, which became overloaded. As

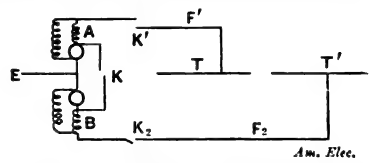


FIG. 1.—ORIGINAL CONNECTIONS.

the accident ocurred at a time when traffic was light, *B* was able to look after its increased load, but it was evident that it would not do so under the strain of late afternoon and evening travel. The engineer plainly saw that unless something was done very promptly, that there was the choice between pulling in half the cars and injuring the remaining dynamo. This procedure was as follows:

In the power house store room was an extra armature belonging to a machine of entirely different make from the injured one. This extra armature was 2 ins. less in diameter, and had a core 6 ins. shorter than the armature it was to replace; besides, its brasses did not fit the pillow blocks on the injured dynamo. Notwithstanding these drawbacks, the grounded armature was removed and the smaller one (of the same voltage and nearly the same rated horse power) put in its place.

The armature was centered by blocking up the shells with pieces of leather belting; a pulley was fitted on and belted to the engine, which was then turned over at a slowly increasing speed, till its behavior in-

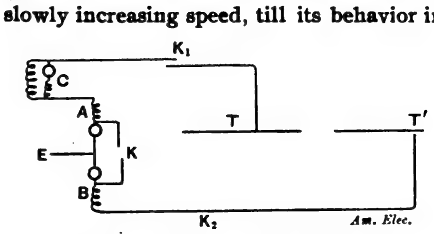


FIG. 2.—FINAL CONNECTIONS.

dicated that the leather blocking would not be a source of trouble.

The shunt field of *A* was then disconnected from *A* entirely, and separately excited from *B*'s armature, as shown in Fig. 2. *A*'s series field shunt was removed, thereby strengthening its field under load and holding its voltage in a measure.

The machine was put in service on section *T* of the trolley. With all shunt rheostat resistance cut out and the series field shunt removed, the armature, under maximum load, gave a voltage as low as 275 and the cars could just creep up the grades.

Next to *A* and belted to a separate engine, was a 125-volt lighting machine of nearly the same current capacity as the street railway generator, and the idea suggested itself to use this machine as a booster in series with *A*. Accordingly, this machine, which we will call *C*, was connected as shown in Fig. 2, and its voltage raised to 125, thereby raising the voltage of the two in series from 300 to 425. The two machines, *A* and *C*, in series, acted as a single machine of increased voltage, and looked after their share of the load till after midnight, when the injured armature which had been repaired was replaced. As *C* had copper brushes, it was necessary to occasionally shift them.

A ROTATING LIQUID CONVERTER.

BY PROF. HENRY S. CARHART.

The purpose of this paper is two-fold: First, to describe a simple device to convert a direct current from any source, such as a storage batttery, into alternating currents of one, two or three phases; and second, to apply the principle involved to a simple explanation of the rotating converter.

Fig. 1 is a horizontal section and Fig. 2 an elevation of the apparatus. A large square jar is nearly filled with a solution of zinc sulphate containing 7 to 10 ounces to the quart.

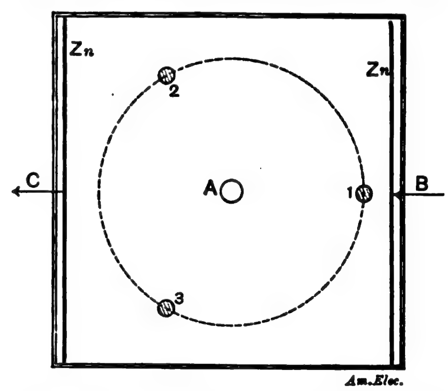


FIG. 1.—HORIZONTAL SECTION OF ROTATING LIQUID CONVERTER.

On opposite sides are zinc plates, *Zn*, which serve as electrodes to convey the current through the electrolyte from the source of constant E. M. F. Dipping into this solution as shown are zinc rods 1, 2, 3, which are screwed fast to a circular insulating plate. This plate is mounted on an axle, *A*, and can be rotated by means of a handle above or by a pulley as desired. The zinc rods are connected through the interior of the axle to rings 1, 2, 3, 4. The brushes bearing on these rings convey the alternating currents to the external circuits.

It is obvious that the current in a circuit connecting any pair of zinc rods is reversed every half revolution. Moreover, its strength follows closely the law of sines. Referring to Fig. 3, let *a* and *b* be two rods, 180 degs. apart. Then it is obvious that in the position, *a b*, there is no difference of potential be-

tween them, since the current flows directly across from one zinc plate to the other, and the fall of potential from the anode to a, is the same as from the anode to b. In the position, $a'' b''$, the potential difference between the rods is a maximum, while in the intermediate position, $a' b'$, it is proportional to their distance apart measured in the direction of the current flow, that is, to the line, $a' c$. But $a' c$ is proportional to the sine of the angle θ. Hence as the rods rotate in the liquid their potential difference is proportional to sin θ, and the current through a circuit joining them will be a simple alternating current following the sine law. If another pair of zinc rods be placed on the same circle at an angular distance of 90 degs. from the first pair, it is evident that the potential difference between them will also follow the sine law, and that the two potential differences will always differ in phase by 90 degs., and the two circuits will convey two-phase currents.

With three zinc rods set at angular distances of 120 degs. and at the same radial distance from A, the potential difference of the three sets or pairs will always differ by 120 degs. In the position shown in Fig. 1, there is no potential difference between 2 and 3, and the difference between 1 and 2 is the same as between 1 and 3. Hence, if three interlinked circuits be connected with 1, 2 and 3, the currents between 1 and 2 and 1 and 3 will be equal, and there will be no current between 2 and 3; that is, all the current flowing out of the liquid by 1 will return to it by 2 and 3. If the circle carrying the rods be rotated 30 degs. counter clockwise, then there will be no current through the branch leading from 3, while the currents in the other two branches are equal and in opposite directions, or the circuit through 1 and 2 forms a shunt to the liquid conductor. It will then be readily seen that the result will be three-phase currents in the circuits joining the brushes 1, 2 and 3, and leading to a star or a mesh arrangement. Actual measurements of the three currents at angular intervals of rotation of 15 degs. give very beautifully, when plotted, the usual curves for three-phase currents. (See Fig. 3, p. 45, in the February number of this journal.) The angular positions of the disk carrying the zinc rods can be easily obtained by means of a divided circle on the cover of the apparatus. A pointer on the axle indicates the angular position.

This apparatus is not intended to furnish alternating currents for ordinary purposes, though it is capable of doing so at low frequencies; it was designed to enable one to produce two-phase or three-phase currents, and to arrest them at any desired relative value in order to study progressively their magnetic effects in producing a rotating field. For this purpose it has proved to be most satisfactory.

Turning now to the second part of this article, it will readily be seen that this device furnishes an analogy by means of which one may perceive more clearly the manner in which a rotating converter produces alternating currents from a direct one or the reverse.

It will be perceived that the three circuits connected to the apparatus at the binding posts, 1, 2, 3, act as shunts to the liquid resistance. If this resistance were negligible, no alternating currents would pass through the external conductors, because there would be no potential difference between the rods, 1 2, 3, or between 1, 2 and 3, 4 when four rods are used for two-phase currents. In a rotating converter the slip rings leading to the two-phase or three-phase circuits are connected with the commutator

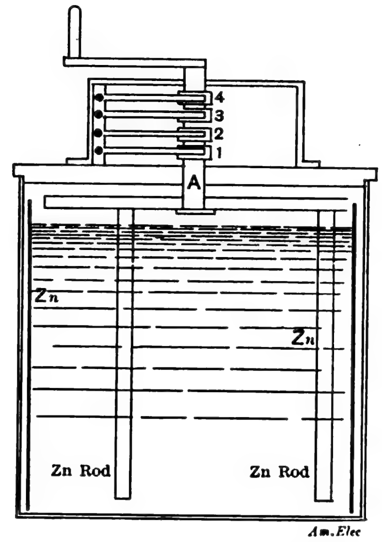


FIG. 2.—ELEVATION OF ROTATING LIQUID CONVERTER.

bars directly in such a way that these external circuits act as shunts to the armature. But the armature has very low resistance. Why, then, do the currents pass through the shunt circuits at all? This question brings us to a consideration of the functions of the magnetic field in a rotating converter. It has at least three. It serves to produce the necessary rotation of the armature as a motor. It also furnishes the necessary reverse induction to prevent sparking at the brushes in precisely the same way as in any

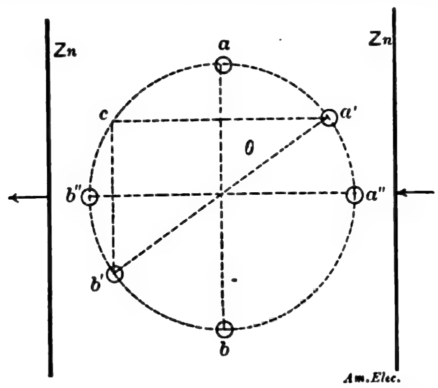


FIG. 3.—ILLUSTRATING ACTION OF ROTATING LIQUID CONVERTER.

other motor. Finally, and chiefly, it supplies a counter E. M. F. which performs the same office in the rotating converter as the resistance of the electrolyte does in a liquid converter. But for this counter E. M. F., nearly all the current would flow directly through the armature without traversing the shunt circuits.

I have thus far supposed that direct currents are converted into alternating ones. It will be readily seen that the liquid converter will also convert single-phase, two-phase or three-phase currents into a direct current if the rotating member of the apparatus revolves synchronously with the alternating current or currents. The operation or flow in every part is then simply reversed. The resistance performs the same office as in the reverse conversion. In a similar way a rotating converter transforms two-phase or three-phase currents into a direct one. It is self-exciting on the direct-current side, and the rotation of the armature in a magnetic field generates the necessary counter E. M. F. essential to the operation of the device.

It is not difficult to see why the virtual E. M. F. of a single or two-phase converter is 0.71 of the constant E. M. F. on the commutator side. The maximum E. M. F. on the alternating side cannot exceed the constant E. M. F. on the direct-current side. The two E. M. Fs. are equal at the instant when the brushes bear on those commutator bars which are directly connected to the slip rings. But as the virtual E. M. F. is only 0.71 of the maximum when the E. M. F. follows the sine law, it can be only 0.71 of the constant E. M. F. A commutator serves to keep the E. M. F. at the brushes up to the maximum value which the armature can generate; while on the alternating side, with two-phase currents, the E. M. F. varies from this maximum in the positive sense through zero to an equal maximum in the other direction.

The relation between the E. M. Fs. easily follows from an examination of Fig. 3. When the zinc rods are in the position, $a'' b''$, their potential difference is a maximum, and is the same as that between the zinc anode and cathode plates if the rods lie close to them. As the rods move away from this position, their potential difference becomes less and less, and the virtual or "square root of mean square" value of this varying E. M. F. is 0.71 of the highest value.

For three-phase currents the greatest potential difference between any two circuits, as in Fig. 1, occurs when the current through one of the circuits is zero. This position is 30 degs. from the one shown in Fig. 1. Hence the problem resolves itself into finding the side of an equilateral triangle when the constant E. M. F. is represented by the diameter of the circumscribing circle. If the diameter is E the radius is $\frac{E}{2}$, and the side of the equilateral triangle, which is $2r$ cos 30 degs. equals $E \times 0.866$. This is the maximum value of the voltage. Its "square root of mean square" value is then $E \times 0.866 \times 0.71 = 0.61\,E$. The same relations precisely hold in a rotating converter.

Such a converter may be used as a generator. Consequently if its voltage is 500 as direct-current generator, it will be 350 as a two-phase and 300 as a three-phase generator. The capacity of the machine as a two-phase or three-phase generator is, however, the same as for a direct-current generator of the higher voltage. For example, as a two-phase generator, the current through the armature is only 0.71 of the sum of the two alternating currents for balanced circuits.

This is due to the fact that the two alternating currents are in quadrature, and therefore the resulting current through the armature is the square root of the sum of the squares of the two external currents. For example, if both external circuits carry 100

virtual amperes, their resultant in the armature is $(\overline{100}^2 \times \overline{100}^2)^{\frac{1}{2}} = 141.4$. In other words, a current of 141.4 amperes in the armature, resolved into two equal components in quadrature, gives 200 amperes in the two external circuits. Hence the machine gains in current as much as it loses in voltage in comparison with its employment as a direct-current generator, and therefore its capacity remains unaltered.

In a particular form of two-phase machine, in which the number of coils on the armature exceeds the number of field poles by two, there is a loss of capacity due to the fact that the E. M. F. suffers a further reduction because a phase difference exists between the instantaneous E. M. Fs. in the several coils.

NOTES.

Influence of Heat Upon the Magnetic Properties of Hardened Steel.—In a paper read before the March meeting of the American Institute of Electrical Engineers by Mr. K. E. Guthe, the result of an investigation is given concerning the effect of temperature upon the power of permanent magnets. One of the conclusions arrived at is that to produce strong magnets, hardened steel after being quenched should be reheated to 450 degs. centigrade before magnetic treatment. By this means it is stated that the magnet will be made twice as strong.

Class Distinction.—In a recent circular issued from the office of the *Electrical World*, calling upon electrical advertisers not to extend their patronage to the AMERICAN ELECTRICIAN, one of the arguments advanced is that this journal reaches after "motor-men, dynamo-tenders, steam engineers, firemen, armature winders, machinists in the electrical manufacturing establishments, and the like." The only parallel to the doctrine implied in this remarkable class distinction by the proprietor of an American journal, is that offered by an ukase of the late Czar of Russia, in which the rights of superior education were restricted to privileged classes.

Steam Engine Economy.—At a recent trial of a 1600-HP McIntosh & Seymour vertical cross compound engine in the Atlantic Cotton Mills at Lawrence, Mass., the consumption of steam, including that used in the high-pressure steam jacket and receiver reheater, was 12.96 lbs. per HP hour. Two tests were made, one at the rated HP and another at 80 per cent. load, the consumption of steam at the underload being only increased one per cent. The high-pressure cylinder is steam jacketed and the receiver has a reheater. The steam furnished was superheated from 7 to 20 degs., and that entering the low-pressure cylinder from 74 to 61 degs. The high economy shown by the tests was doubtless largely due to the superheating the steam received, both initially and through the high-pressure jacket and the reheater in the receiver.

Look out for Brambel.—Grant Brambel, the telegraph operator at Sleepy Eye, Minn., who recently announced the discovery of a remarkable type of steam engine, now threatens to enter the electrical field with an "Arcodescent electric system, in which the same dynamo and same wiring can be used at the same time for both arc and incandescent lights." It will be remembered that for some time the wires leading from Sleepy Eye were kept hot by press messages concerning the Brambel engine, one of which, on exhibition "weighed but 12 lbs., 5 oz., and developed 23 HP"—the culminating announcement being that an offer of £320,000 had been received to the lucky Brambel for his invention. A description of the engine recently published shows it to be a crude form of rotary engine, but which, it is stated "instead of relying entirely on boiler pressure, takes the fullest advantage of the expansion power of steam!"

The Texas Street Railway Association.—At a meeting of the Texas Street Railway Association held at Austin, Tex., Mar. 17, a number of topics of interest to street railway men were discussed, among others the policy of increasing traffic by encouraging amusements. The experience of those present showed that balloon ascensions paid electric railways, and that while base ball was a good thing, it was sometimes rather expensive on account of the demands of base ball people; popular price theatre shows were found not to pay. In discussing the matter of bearings, one member advised the use of all brass in replacing bearings, and another stated that after brass bearings have worn down he fills them with babbitt and gets very satisfactory results. In comparing notes it appeared that trolley wheels lasted from three to six months. In a discussion on double and single trucks, considerable difference of opinion was developed, some members being in favor of double trucks and others thought they were not practicable with short cars.

Incandescent Lamp Filaments.—As the usual incandescant lamp filament is raised in temperature its resistance is decreased up to a certain point, beyond which there is an increase of resistance with further increase in temperature. In a paper read before the February meeting of the American Institute of Electrical Engineers, Mr. John W. Howell showed that the cause of this behavior in the case of treated lamp filaments is the graphitic nature of the layer of carbon added during the treating process; pure graphitic filaments have been found to possess the property referred to in a high degree. In the same paper Mr. Howell described some experiments on cathodic discharges from one leg of a lamp filament to another, this phenomenon sometimes being called the "Edison effect." He found that this discharge is most active at a definite state of exhaustion, indicated by a dark blue glow in the interior of a lamp bulb, and that its activity depends more upon the state of incandescence of a filament than upon the voltage between its legs.

Telephone Cables.—In a paper read by Mr. Geo. D. Hale before the March meeting of the Chicago Electrical Association, on "Cable Testing," it is stated that the demand for a high grade cable for telephone work has been solved by manufacturers in the type now in use. It consists of a bundle of separately insulated copper wires, varying in number from 5 to 200 pairs, the usual size of wire being No. 19. As ordinarily constructed, each wire is taped with a paper ribbon, the wires of a pair being wound spirally around each other, each concentric layer being wound on spirally right and left-handed alternately, the whole then wrapped with cotton yarn and enclosed in a lead covering. By far the larger proportion of these cables are without any paraffine or other insulating compound, but are simply baked until free from moisture. The main advantages of this type of cable are its low electro-static capacity and its high insulation resistance. Its weak point is that a small opening in the lead sheath practically ruins a cable in a few hours. Where a low capacity is not essential, the cables are usually saturated with paraffine, so that in case of a hole being made in the sheath, the entire section of the cable will not be rendered worthless. However, as paraffine absorbs moisture to some extent, the opening should be located and repaired as early as possible to prevent the loss of a considerable length of the cable. The paper gives instructions for tests of cables, both in the factory and when laid.

Standardizing Incandescent Lamps.—The American Institute of Electrical Engineers has laid down the following principles upon which to base a commercial method for the candle-power rating of incandescent lamps: 1°. The Hefner-Alteneck amyl-acetate lamps furnished with test certificates from the Physikalisch-Technische Reichsanstalt at Charlottenburg, Berlin, should be temporarily adopted as concrete standards of luminous intensity, or candle power. 2°. That in measuring the mean horizontal luminous intensity or candle power of an incandescent lamp, a Lummer-Brodhun photometer screen be adopted, and that the incandescent lamp be steadily rotated about a vertical axis through its axis of figure at a uniform speed of approximately two revolutions per second. The Committee on Units and Standards, which formulated the above requirements, adds that it believes the adoption of these recommendations would lead in practice to a much greater degree of uniformity in results of measurements of the candle power of incandescent lamps, by different and remote observers than is now usually attainable. The Committee also recommends that although incandescent lamps are at present rated by their horizontal candle power, yet, since the only true criterion of the total quantity of light emitted by a lamp is its mean spherical candle power, the rating of lamps should be based upon their mean spherical candle power so far as is commercially practicable. The above recommendations were only arrived at after a lengthy study by the Committee of Units and Standards of all the elements entering, and though short, represent the result of many meetings of that Committee. It is understood that the principles thus laid down will be used as a basis for a commercial method of lamp standardization, to be prepared by a Committee representing in part the commercial interests involved.

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Publisher's Notice.

Electrical Doings having been absorbed by the AMERICAN ELECTRICIAN, subscribers to that journal will receive the AMERICAN ELECTRICIAN during the remaining term of their subscription.

Polyphased Currents.

In another column Prof. Carhart describes a beautiful arrangement for illustrating the generation of polyphased currents and the action of the rotary converter, which should go far toward dispelling any mystery that may remain in the mind of the reader concerning these subjects. The battery arrangement described also enables the rotary magnetic field to be studied in an ideal manner, this, in fact, having been the object for which it was devised; the results obtained from such study furnished the subject of a paper by Prof. Carhart giving the best exposition of the rotary magnetic field yet printed. One of the troubles met with in the study of polyphased currents has been the difficulty of fixing the mind on simultaneous values of the several rapidly varying currents, each being apt to be considered by itself. The apparatus devised by Prof. Carhart enables this to be done, for the several currents corresponding to any part of a cycle can be retained constant at their simultaneous values for any desired period of time. As the apparatus is not an expensive one to construct, it should enter largely into use to illustrate the properties of alternating currents, for it applies equally well to single and three-phased currents, and can be adapted to two-phased currents.

Practical Electricity.

The custom appears to be growing for mechanical journals to devote some of their space to "practical electricity," and, we fear, with disastrous results in some instances. The editor having presumably no knowledge of the subject, he is at the mercy of his contributors; and in selecting these he is apt to follow too literally the precept that a writer on practical electricity should be a practical man. Each person has his own method of associating a phenomenon in his mind by analogies with other and, to him, more familiar phenomena. Some, however, are inclined to accept such analogies as identities, and among these are, as a rule, the class of writers to whom we refer. Analogies when not handled carefully are in themselves dangerous, and when one with limited knowledge on the subject attempts to reconstruct the science of electricity according to ideas that strike him as reasonable merely because they conform to his manner of looking at another and perhaps diametrically opposite set of phenomena, the result is apt to be rather bizarre; when to this is united a spirit of independence of all electrical authority, it becomes remarkably so.

As an example of the class of writing referred to, we quote the following from the English *Hardware Trade Journal*: "In giving a definition of 'the ohm,' we stated that the resistance of a copper wire $\frac{1}{18}$ in. diameter is 1 ohm, and that a current of 1 ampere, with an E. M. F. (pressure) of 1 volt delivered at one end of such a wire, would result in no current being delivered at the other end as the forces exactly counterbalance each other. This is an error in description, as the ampere of current requires 1 volt to overcome the resistance of 1 ohm and maintain the current in any part of its length of wire. Further, a fall of potential would occur by an increase in the length of the wire, which would eventually establish a balance, and no current would result—that is to say, the resistance would overcome the power. This is an important point for would-be electric light fitters and wiremen."

Electricity Direct from Fuel.

Elsewhere in this number will be found an admirable article by Mr. C. J. Reed on the subject of thermo-electric cells, which forms a timely contribution to a topic much discussed at present under the alluring title of "Electricity Direct from Fuel." Information concerning the subject treated is very meagre in English technical literature aside from publications not easily accessible, and Mr. Reed's article therefore performs an excellent service by resuming the main facts known up to date. The article classifies the various cells that have in more recent years come before the public, including those of Jacques and Case, and concisely and clearly points out the principles upon which they rest, thereby enabling the reader to form an intelligent opinion concerning the value of claims made for some of the types described.

The conclusion arrived at by Mr. Reed is not encouraging to expectations which may have been awakened by the sanguine discussions concerning the production of electricity from heat cells. The only hope held out—the discovery of new chemical elements having properties radically different from those of any known substance—is extremely remote, notwithstanding the recent discovery of the new element of argon in the atmosphere. At any rate, before any further discoveries in this line are hailed as a solution of the problem, the test of the second law of thermodynamics should be applied, and a rational explanation offered for any actions that may by thought to give an efficiency higher than its indications, or independent of its limits.

The law of thermodynamics referred to is simply, that the amount of the heat available for transformation into another form of energy, is to the whole amount

supplied, as the working range of temperature is to the highest temperature expressed in absolute measure—that is, the Fahrenheit temperature registered increased by 461 degrees. It must not be expected, however, that if the temperature is very elevated the efficiency will be correspondingly increased, as this would imply that the available heat is utilized at the same efficiency at high as at low temperatures. This does not by any means necessarily follow when dealing with such an agent as heat, even should no question arise as to the durability of materials under the high temperature.

Calculation of Transmission Lines.

From time to time requests are received asking the amount of copper required to transmit a given horse power a given distance. Invariably the only data supplied are the number of horse power and miles, and the presumption is that the cost of copper is thought to be the predominating factor. This understanding appears to be widespread, and probably arises from the interest that has been taken in discussions concerning transmissions over very long distances, in which, being merely for popular edification, the question of line has alone figured. It will usually happen, however, that about the last thing to consider in deciding upon the commercial feasibility of a transmission plant is the line conductor, while, as stated before, that appears to be generally the first thought of.

If, as is usually the case, an undeveloped water power is in view, first comes the cost of development which, according to Bell, may be from $20 to $150 per horse power, and at $100 can nearly always drive steam power out of business. Assuming a lower figure than the latter, or $100 per kilowatt, this item for a 1000-KW plant (1350 HP, about) will amount to $100,000. Wheels, power house and fittings will add, say, $15,000 to this, and electrical generating and transforming apparatus $30,000 more. We thus have $145,000 before the poles and distributing lines are reached, and in many cases this partial result will be sufficient to determine the feasibility of a scheme. Still another step may be made before the calculation of the copper necessary for transmission is taken up, and that is to determine the cost of the pole line, which will vary from $250 to $500 per mile; at this stage the cost of the distributing system might also be added, this including lines from step-down transformers and cost of motors, if supplied by the transmission company.

The above estimate looking favorable for the scheme, the final step, or calculation of copper, may be undertaken. This is by no means a mere question of substitution in a formula in which the drop factor is assumed, but on the contrary is a question calling for ripe engineering judgment where the amount of money at stake is considerable. This will be evident if it is considered that the energy lost through the resistance of the line has to be paid for at the generating end, both in the cost of producing that energy and in the cost of extra equipment for that purpose. Consequently, as the drop is increased, though the cost of copper becomes less, the generating factor is increased and *vice versa*. There is a certain point in every case at which the yearly cost of copper investment is just balanced by the cost of energy lost in transmission, and this fixes the amount of copper to be used. In such a calculation, therefore, a drop factor is not considered and, in fact, if desired to be known, has to be determined by calculation after the size of the line is finally determined.

From what precedes we believe it will be seen that an estimate for a transmission scheme of any magnitude, to be worthy of confidence, is essentially a matter to be confided to an engineer; and by engineer is not meant one merely having that title through the possession of a degree or by assumption, but one who answers to the truer definition of the term—a man who unites a trained and sound judgment with technical knowledge.

The Standardization of Incandescent Lamps.

In another column will be found the report of the Committee on Units and Standards of the American Institute of Electrical Engineers on the subject of the standardization of the candle power of incandescent lamps. The necessity for some authoritive action with a view to enabling large users to definitely determine the candle power of incandescent lamps purchased, has long been recognized, for upon this determination depends that of the watt efficiency of lamps. Variations in measurements taken in even well equipped laboratories under skillful supervision have been found to be as large as 20 per cent. and even more; laboratories, in fact, had come to be classified by lamp manufacturers as "high" standard and "low" standard, though with no implication of designedly departing from a true standard. This state of affairs has doubtless arisen from three causes—the use of different primary sub-standards and photometric screens, and different ideas concerning the actual method of measurement.

To provide for the first of these, in the lack of means of procuring certified photometric sub-standards in this country at present, a specific lamp easily procurable at a low price from a German source of high technical authority is prescribed—the certificate of standardization which accompanies this lamp doubtless having furnished the controlling reason for this action. A definite photometric screen is recommended, most probably with a view to uniformity rather than from any particularly great intrinsic merit possessed by the screen selected. Finally, in order to enable the mean horizontal candle power to be determined without taking measurements of a lamp at different angles, it is recommended that a lamp be uniformly revolved about its vertical axis at a certain definite rate, this rate having been found to give a practically constant illumination on a photometric screen.

From the above it will be seen that the committee confined its action to fundamental points alone, thus leaving the work of laying down definite practical rules for standardization, to those whose interests are directly concerned. A recommendation is added that the candle power of an incandescent lamp should be based upon the mean spherical candle power which, if the horizontal candle power is to serve for secondary standardization (as seems alone to be practicable), means the introduction of factors depending upon the shape of filament. Owing to the many different styles of filaments now made, the fixing of this factor would almost undoubtedly give rise to commercial recriminations, and it seems the part of wisdom for the Institute to avoid becoming embroiled in this manner, even though at the risk of being considered unduly conservative.

The work left unaccomplished, lies, it would seem, with a committee on which all the different interests concerned will be represented. Owing to the difficulty or impossibility of arriving at a conclusion on some of the points involved that will be unassailable from every point of view, some of the decisions of such a committee may necessarily, if practical results are to be rendered possible, have an arbitrary character. Its membership should, therefore, be such as to give weight to its decisions, and be so distributed that no interest can consider that it has been slighted. A committee of the desired character would appear to be one having representation from the National Electric Light Association, the American Institute of Electrical Engineers, the Edison Association of Illuminating Companies, the lamp manufacturers, with possibly the addition of an authority on photometry, such as Prof. Nichols or Fessenden.

DESIGNS FOR SMALL MOTORS.—II.

ONE-SIXTH-HP MOTOR WITH RING ARMATURE.

BY CECIL P. POOLE.

In the accompanying sketches, *M* is a wrought iron magnet core, *P*, *P*, cast-iron pole-pieces, *C*, the armature core, and *Y*, the journal yoke. The magnet core, *M*, is made from a ¾ in. × 4½ in. bar of commercial wrought iron, bent to the shape shown. The faces of the arms are machined to a depth of $\frac{1}{16}$ in. where the pole-pieces, *P*, *P*, are attached, so as to form a magnetic joint of as low reluctance as possible. The pole-pieces are secured to the magnet arms by ¼-in. cap screws passing through smooth holes in the arms and tapped into the pole-pieces; the latter are of grey cast-iron, and should be finished on all sides sufficiently to remove the scale. The magnet, *M*, might be improved in appearance by touching up its sides with a coarse emery wheel; it should be thoroughly annealed after bending and finishing. It will be noticed, by reference to Fig. 2, that the ends of the magnet arms project slightly beyond the outer faces of the pole-pieces; this is done in order to furnish a guide for the flanges of the journal yoke arms. After fitting the pole-pieces to the magnet arms, the complete magnet frame is bolted to the lathe carriage in position for boring out the pole-pieces; before this is done, it is necessary to drill a hole through the back of the magnet to allow the boring bar to pass through, and also to form a seat for the rear bearing. This hole is ¾ in. in diameter, and the magnet frame must not be allowed to move from its original position on the lathe carriage from the time the hole is drilled until all the circular tooling on it is accomplished.

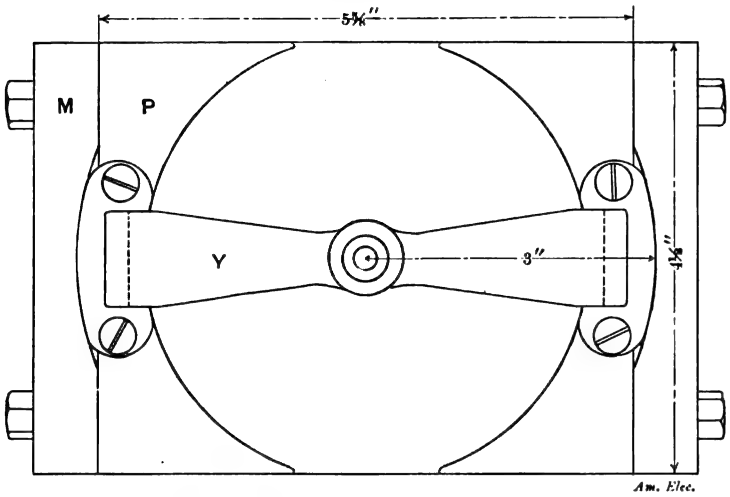


FIG. 1.—FRONT ELEVATION OF FIELD MAGNET.

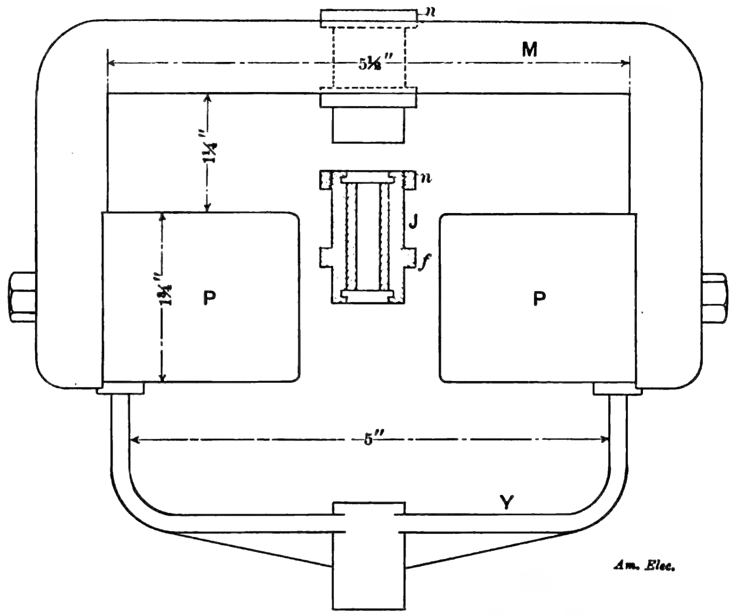


FIG. 2.—PLAN VIEW OF MAGNET AND JOURNALS.

After drilling the hole in the back of the magnet, adjust the boring bar and bore the armature chamber out, 4$\frac{1}{16}$ ins. in diameter. Next adjust the boring tool so that it will scribe on the ends of the magnet arms arcs of a circle 6 ins. in diameter; then cut away the wrought iron inside the scribed marks, down flush with the pole-pieces, as shown in Fig. 1, forming recesses for the flanges of the journal yoke. The yoke and box are cast in one piece of brass or other non-magnetic composition; the shell of the box is 1¼ ins. long, and projects ¼ in. beyond the inner face of the yoke; the outer diameter of the shell is ¾ in. and it is bored out to $\frac{7}{16}$ in. inner diameter and bushed to ¼ in. The yoke and arm portions are $\frac{3}{16}$ in. thick, with a ⅛ in. stiffening rib on each side of the box, and the arms taper from 1 in. wide at the flanges, to about ½ in. near the box. The flanges are 2 ins. long, ¾ in. wide and ⅛ in. thick after facing; the arms, beyond the bends, are sufficiently long to make the distance from the face of the pole-piece to the inner face of the yoke 2 ins. After boring the box, it is mounted on a *stiff* mandrel and the surfaces of the flanges that go next the magnet are faced up true; next, the outer edges of the flanges are skimmed off until the yoke fits snugly between the curved edges of the recesses previously cut in the ends of the wrought-iron magnet. Care must be taken in making the pattern for the yoke that the inner edges will not project inward beyond the bore of the pole-pieces. The yoke is fastened to the pole-pieces by screws, as indicated in Fig. 1.

The rear bearing, *J*, is a little peculiar in construction. The box portion is similar to that part of the yoke, but it is cast with a flange, *f*, 1 in. from the farthest end of the shell, which is 1½ ins. long. A collar, *n*, is fitted to screw onto the outer end of the shell, which is threaded for that purpose. The shell is turned down outside to fit snugly in the hole drilled in the back of the magnet, and when it is inserted in the hole, the collar, *n*, is put on and screwed up tight. This box, like the front one, is bushed to ¼ in. bore. The drawing shows the flange, *f*, and collar, *n*, countersunk in the metal of the magnet; this will not be necessary if the magnet is smoothed up with an emery wheel, as above suggested, the object in countersinking being to provide smooth, true bearing surfaces for the flange and collar.

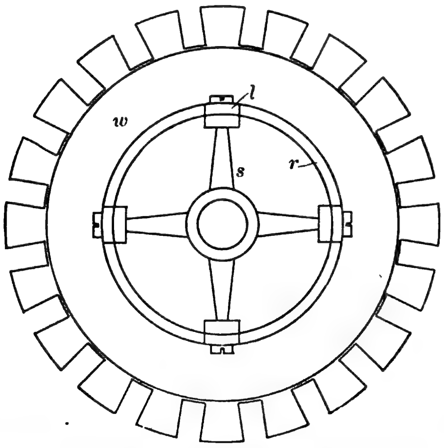


FIG. 3.—END OF ARMATURE CORE AND SPIDER.

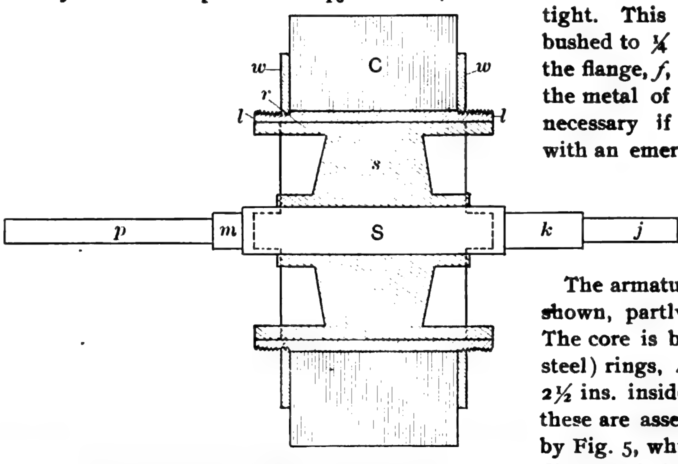


FIG. 4.—ARMATURE CORE, SPIDER AND SHAFT.

The armature core, spider and shaft are shown, partly in cross-section, by Fig. 4. The core is built up of charcoal iron (not steel) rings, 4½ ins. outside diameter and 2½ ins. inside, not more than $\frac{1}{32}$ in. thick; these are assembled on a brass drum, shown by Fig. 5, which should be 2⅝ ins. outside diameter before finishing, so that it may be turned down to exactly fit the inner circle of the armature rings; the wall of the drum is ⅛ in. thick after finishing, and there are four equidistant projecting lugs, *l*, ½ in. long, on each end by which the drum is secured to the spider (see Figs. 3 and 4). The rings forming the core, *C* (Fig. 4), are compressed and held on the drum, *r*, by two brass washers, *w*, *w*, $\frac{3}{16}$ in. thick and 3⅝ ins. outer diameter, which screw onto the ends of the

drum. The core, when compressed, is 1¾ ins. long, and has twenty slots, ¼ in. wide and 7/16 in. deep; the washers, *w*, *w*, must be set up as tight as the threads will stand.

The spider, *s* (Figs. 3 and 4), is made of brass, and consists of a hub (¾ in. diameter, 2 ins. loug and ½ in. bore) and four arms

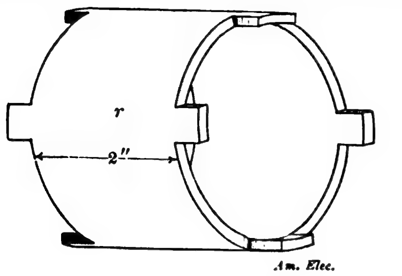


FIG. 5.—BRASS DRUM.

having T-shaped ends, the wide part or heads of which project beyond the arms and hub at each end, the length of these heads being 2⅞ ins. and their width ⅜ in. The heads of the spider arms are turned off to fit very closely inside the drum, *r*, which is mounted on the spider in such a position as to bring the spider arms in alignment with the lugs, *l*, of the drum; screws through the spider arms into the lugs hold the drum and spider together.

The shaft, *S*, is 8½ ins. long; the portion, *j*, is 1⅛ ins. long and ¼ in. diameter; *k*, is 1 in. long and ⅜ in. diameter; the part pass-

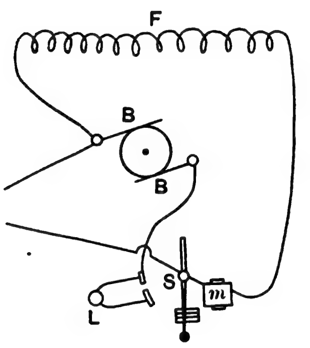


FIG. 6.—STARTING SWITCH.

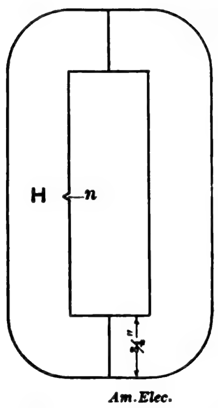


FIG. 7.—FIBRE HEAD.

ing through the core is 3 ins. long and ½ in. in diameter; *m*, is ⅜ in. long and ⅜ in. diameter. and *p* is 3 ins. long and ¼ in. diameter. The spider, *s*, may be secured to the shaft by a key or a set-screw; the set-screw is sufficient in so small a machine. The commutator (not shown) must not be more than ¾ in. over all, along the shaft; it must have ½ in. brush surface and 20 segments; other details may be made to suit the will of the builder. The front end of the commutator must be not less than 7/16 in. from the shoulder where *j* and *k* join.

The armature is next prepared for winding by removing the drum and core from the spider, and insulating the ends and interior of the core and the walls of the slots. Cut four rings of heavy drilling of a size to cover the washers, *w w*, and the ends of the drum, *r*; varnish two of them on one side with shellac, and apply them to the ends of the armature body. While these are hardening, cut forty strips of drilling 1⅛ ins. wide and 2¼ ins. long; in each end of each of these cut two slits ¼ in. long parallel with the sides and located 7/16 in. from each side of the strip. Varnish these on one side, and when nearly dry, fold them into troughs to fit the slots, two troughs to a slot, one within the other; fold them so that the varnish will be on the inside of the trough.

When these are dry, varnish the slots and the outsides of the troughs and put the latter in the slots, bending the ends flat against the core and securing them there with a little fresh varnish. Then varnish the ends of the core (two cloth rings being on them), and one side of the two remaining rings of drilling; put these rings on top of the first ones, varnish them on the outside, and put the core in an oven to bake. The armature coils consist of No. 24 double cotton-covered wire, wound six turns wide and twelve layers deep. Before winding them, four strips of wood 3 ins. long, ⅜ in. wide and ½ in. thick should be screwed to the inner wall of the brass drum, in line with the lugs, *l*, so as to preserve spaces for the four arms of the spider. A double thickness of drilling should also be applied to the interior of the drum to insulate the coils from it. The connections are the simple Gramme ring arrangement.

The field winding is necessarily divided into two coils on account of the rear bearing passing through the magnet. Each coil consists of No. 28 double cotton-covered wire, wound 17 layers deep and 181 turns or more long; the two coils are connected in series with each other and in shunt to the brushes. Heads of hard fibre ⅛ in. thick should be used to protect the ends of each coil; one of these is shown by *H*, (Fig. 7), but the width should be 7/16 in. instead of ¾ in. as marked.

It is in two pieces, the seams being at the ends, and is cut from ⅛ in. sheet fibre. The two halves may be clamped together on the core by means of a small brass wire drawn around the outer edge, laying in a shallow groove, the ends being twisted and cut close. The pole pieces should be removed before taping and putting on the heads, to facilitate these operations as well as the winding of the coil. One fibre head has a notch, *n*, half way of its inner long side to enter the field wire. The pole-pieces should, of course, be removed before winding the field coil, and the magnet core should be wrapped with two layers of varnished drilling where the coils are to go. The entering end of each coil should be remote from the journal, and this means that the magnet must be turned end for end after one coil is wound, or else the two coils must be wound in opposite directions in order that the free ends at the center of the magnet may be connected together. It is advisable to provide a starting switch similar to the one shown diagrammatically by Fig. 6, where *F* is the field coil; *B*, *B*, the brushes; *S*, the starting switch lever; *L*, a 32-CP 110-volt lamp; *m*, a magnet; and *S W* a double-pole snap switch.

The motor is intended to be mounted on a wooden base-board 8 ins. × 8 ins. a cleat 3 ins. wide and 7/16 in. thick being put under the pole-pieces to raise the frame so as to clear the field coil. Bolts from beneath, tapped into the magnet and countersunk in the under side of the base, should be used to hold the motor on the base. The pulley may be any diameter from 1 in. to 3 ins. by 1 in. face, if crowned, or ½ in. if grooved.

AMERICAN TELEPHONE PRACTICE.

CALLING APPARATUS.

KEMPSTER B. MILLER.

So far we have dealt solely with the apparatus by which the actual transmission of speech is accomplished. While these are, of course, the most vital parts of a complete telephone, they would be of little use were not means provided whereby one party might call the attention of another in order to bring about a conversation. Many attempts have been made to devise telephone instruments capable of reproducing speech so loudly that one has only to call into the transmitter in order to attract the attention of a party at the other end of the wire. Such attempts have so far resulted practically in failure, and this is perhaps fortunate, as one

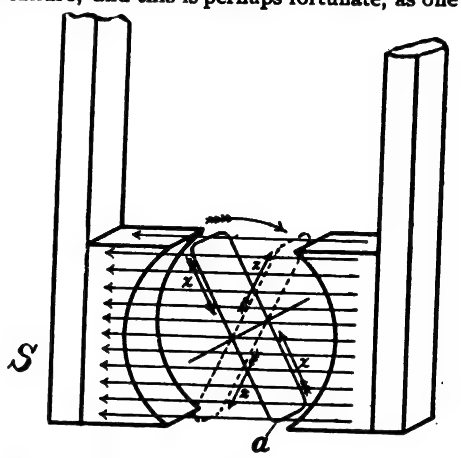


FIG. 1.—FIELD OF FORCE IN MAGNETO-GENERATOR.

of the most convenient features of telephones to-day is that a conversation can be carried on in secrecy, at least so far as the receiving is concerned.

Ordinary vibrating bells, using current derived from a battery, were at first used for calling, and as the battery for operating the transmitters could also be used for this purpose, this plan seemed to offer many advantages. It was found, however, that the amount of energy furnished by a telephone battery was insufficient to operate call bells at great distances. Of course, practically as high voltage as was desired could be obtained, by using induction coils and causing induced currents from the secondary to pass out over the line. This, however, reduced the current in the same proportion as it raised the voltage, leaving the amount of energy the same.

What is known as a "magneto-generator" is now almost universally used, both in this country and abroad. It is the simplest

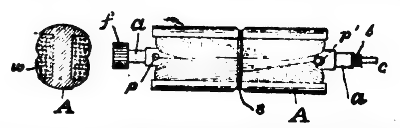


FIG. 2.—ARMATURE OF MAGNETO-GENERATOR.

known form of the dynamo, and consists of an armature of the Siemens type, wound with many coils of fine wire, and so mounted as to enable it to be rapidly revolved between the poles of a permanent horseshoe magnet. Its theory of action is very simple and depends on the principles of magneto-electricity discovered by Faraday and Henry,

and pointed out in a previous article—that if the number of lines of force passing through a coil of wire be varied, currents of electricity will be generated in this coil, the direction of these currents depending

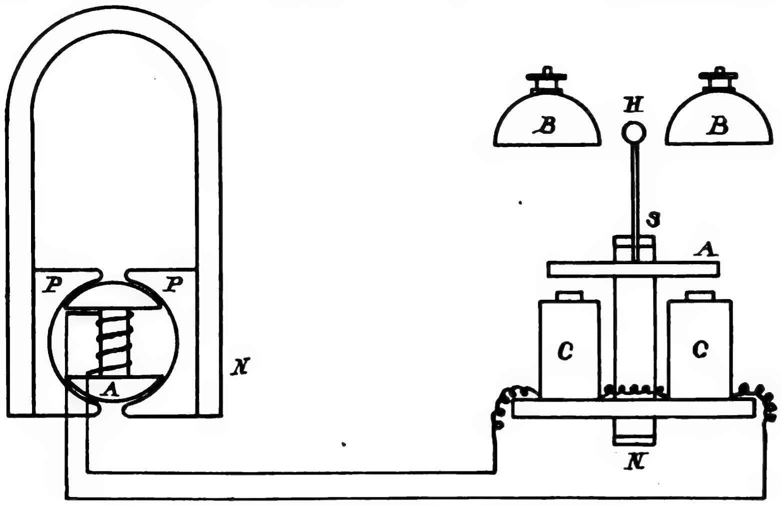


FIG. 3.—DIAGRAM OF GENERATOR AND CALL BELL.

upon the direction of the lines of force and on whether their number is decreasing or increasing.

In Fig. 1 is shown a simple loop of wire, *a*, which may be revolved about a horizontal axis in the field of force of the permanent

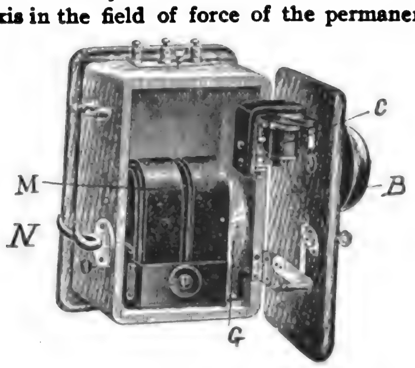


FIG. 4.—MAGNETO-GENERATOR AND CALL BELL.

magnet, *N S*. The horizontal arrows represent the direction of the lines of force set up by the magnet through the loop. Suppose the loop to be turned in the direction of the curved arrow. When it is in horizontal position no lines of force will pass through it.

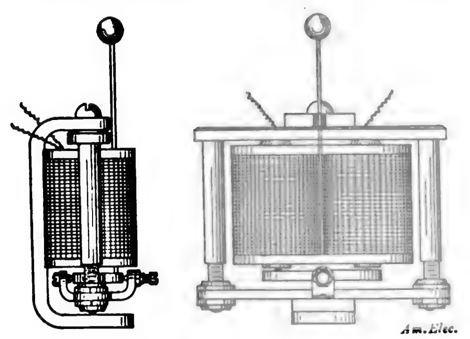


FIG. 5.—CALL BELL.

As it approaches the position shown by the full line it will include a larger and larger number of these lines. The current induced in the coil will then be in the direction indicated by the arrows, *x*, and will so continue until the loop is in its vertical position. The number of lines passing through the loop then begins to decrease and the current therefore takes the opposite direction as indicated by the arrows, *z*. The current increases in strength in this new direction until the coil is horizontal. At this point the rate at which the number of lines through the coil is changing is greatest, and the current is therefore a maximum. As the coil passes through the horizontal position the number of lines passing through it begins to increase again. This would cause another change in the direction of the current, were it not for the fact that the direction of the lines of force through the coil also changes. The same events take place during the next half turn, when the coil is in the position from which it started.

We thus see that the current generated is an alternating one, changing its direction twice during every revolution. The armature, instead of having a single turn of wire, as in Fig. 1, has a great number of turns of fine wire wound on a cast iron core of the form shown in Fig. 2. In this figure *A* represents a shuttle-shaped core of cast iron, on which the coils of wire, *w*, are wrapped. One end of the wire forming the coils is fastened to the pin, *p*, which is fastened to and is in metallic connection with the core, *A*. The other end is fastened to the pin, *p'*, which is insulated from the core, but connects with the pin *c*, projecting from the end of the armature shaft and which is insulated therefrom by the fibre bushing, *b*. Projections, *a a*, integral with the core, are turned down to form bearings for the armature. A pinion, *f*, is carried on the end of the shaft in order to transmit to the armature the motion received from a large driving gear wheel with which it meshes.

A magneto-generator in connection with a call bell is shown diagrammatically in Fig. 3. To the poles of the permanent magnets, *N S*, of the generator are attached cast iron pole pieces, *P P*, bored out so as to allow the armature, *A*, to turn freely between them. The bearings of the armature are usually mounted on brass plates firmly attached to the ends of the pole pieces, but not shown in this figure. By means of a crank attached to a suitable gear wheel engaging a pinion on the armature shaft, the armature may be made to turn rapidly.

As the currents generated are alternating, a polarized bell or ringer is needed. *C C* are the two coils of an electromagnet. Pivoted in front of the poles of this magnet is a soft iron armature, *A'*, carrying a hammer, *H*, on the end of a thin rod extending at right angles from its center. A permanent magnet, *N S*, is so mounted as to magnetize by induction the armature, *A'*, and the cores of the coils, *C C*.

The two poles of the electromagnet will thus have a given polarity, say, north, while the two ends of the armature will

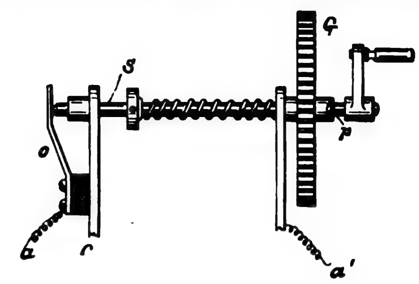


FIG. 6.—ARMATURE SHUNTING DEVICE.

have an opposite polarity, south. As a result, the armature will have a tendency to stick to one pole or the other of the magnets. The two coils are oppositely wound, and when a current passes through them it strengthens the magnetism of one pole and weakens that of the other. The next instant the current reverses and the strong pole becomes the weaker, and *vice versa*. As a result the armature vibrates with each reverse of current and causes the hammer, *H*, to strike the bells, *B B*.

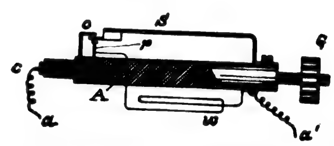


FIG. 7.—ARMATURE SHUNTING DEVICE.

A complete magneto generator and call bell, mounted in a box, is shown in Fig. 4, in which *M* refers to the permanent horseshoe magnets and *G* the driving gear wheel, connected with a crank projecting through the side of the box. The magnets, *C*, of the call bell are mounted on the inside of the lid, the hammer extending through a hole therein to strike the gongs, *B*. Fig. 5

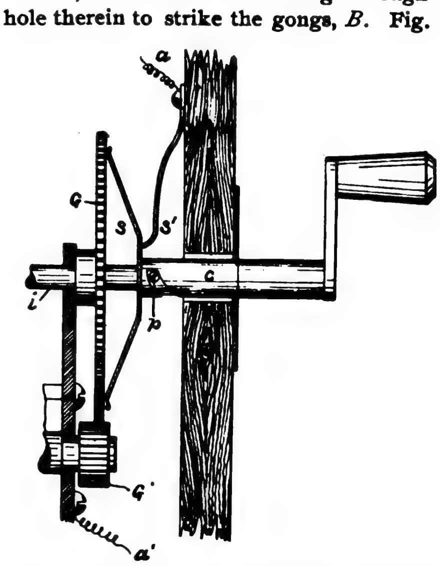


FIG. 8.—ARMATURE SHUNTING DEVICE.

shows one of the commercial forms, and a very efficient one, of call-bell mechanism. The forms of ringers used by different manufacturers, differ widely: but all depend on the same principles for their mode of action.

The armatures of an ordinary hand generator are ordinarily wound to resistances varying from 300 to 650 ohms. The resistance of the ringer coils is usually from 75 to 100 ohms, but is sometimes as high as 1600 ohms, varying according to their use.

On account of the high resistance of the armature and its great retarding effects, it is desirable to have it shunted out of the line when the generator is not in use. Especially is this desirable on party lines where two or more instruments are used on a single line. To accomplish this many devices have been used, both automatic and manual. The automatic devices have now almost entirely supplanted the manual, as the latter were never satisfactory, owing to the inability of ignorant and careless persons to properly manipulate them. Three styles of automatic shunting devices have come into general use and are shown in Figs. 6, 7, 8.

Referring to Fig. 6, the gear wheel, *G*, is mounted on the crank-shaft, *S*, and is free to turn thereon through a small portion of a revolution. Terminals, *a a'*, are connected to the terminals of the armature winding which is, of course, connected in the line wire. When the generator is at rest a current coming over the line will pass from *a'* through the crank-shaft and out through the spring, *o*, to the terminal, *a*; this path being of almost no resistance, while that of the armature winding is large. When the crank is turned, however, the pin, *p*, rides out of the notch in the hub of the gear wheel and in so doing pulls the shaft out of contact with its spring, *o*, thus breaking the low resistance path or shunt around the armature, and leaving the latter effectively in the line.

In Fig. 7, *A* is the core of the armature and *G'* its pinion. *W* is a diagrammatic representation of the winding. While at rest current from the line, instead of passing through the coil, *w*, will take the path from *a'* through the core, *A*, to the spring, *S*, thence to pin, *p*, on which *S* normally rests and thence out through pin, *c*, to the terminal, *a*. When the armature is revolved the centrifugal force of the end of spring, *S*, causes contact to be broken between it and pin, *p*, which opens the shunt around the armature winding.

In Fig. 8 *G* is the large gear wheel and *G'* its pinion on the armature shaft. The low resistance path around the armature is from point *a* through spring, *S'*, screwed on the inside of the generator box, through spring, *S*, gear *G* to the frame of the machine and out at *a'*. When the crank is turned, the collar *c*, which is loose on the shaft, *i*, but rigid with the crank, forces the spring, *S*, away from the spring, *S'* by virtue of the pin, *p*, mounted on the shaft, *i*, engaging the spiral slot in the collar, *c*.

Of the three forms of automatic shunt break shown, those represented by Figs. 6 and 8 are the best, being more positive of action and at the same time insuring better contact.

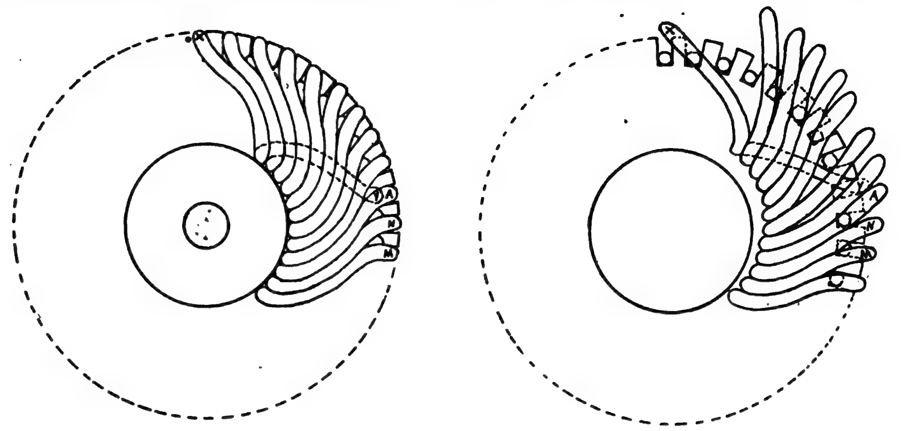
Condenser Dielectrics.

Assuming air as unity, the specific inductive capacity of paraffined paper is 2, glass from 6.5 to 10, mica 5, shellac 3 and gutta percha 4. For equal thicknesses, the capacity of a condenser is directly proportional to the above figures.

THE REPAIR OF ELECTRIC RAILWAY MOTORS.

SYMMETRICALLY-WOUND ARMATURES.

Even when well acquainted with the winding diagram, it is not easy to remove a burned out coil from a symmetrically wound armature unless one has had practical expe-



FIGS. 1 AND 2.—EICKEMEYER ARMATURE COILS.

rience. It is a still more difficult matter to form a new coil and replace the damaged one. Therefore a few hints as to the method of doing this may prove acceptable.

The armature heads seem so symmetrical and the coils so tightly wedged in place, that one hardly knows where to start or how to proceed. The hardest of all armatures of this class to repair is the original Eickemeyer winding, in which the coils pass symmetrically over the ends of the drum in spiral curves. The coils are often so stiff with varnish that even the experienced man is liable to damage a coil or two in removing a faulty one, and the green hand is almost certain to do so.

The slotted armature, which is the only one to be considered in railway work is, in this winding, wound with coils of the shape shown in Fig. 4. One side of this approximately rectangular coil is always free to be lifted out of this slot if the band wires are removed, as it rests in the top of a slot. But the other side is in the bottom of a

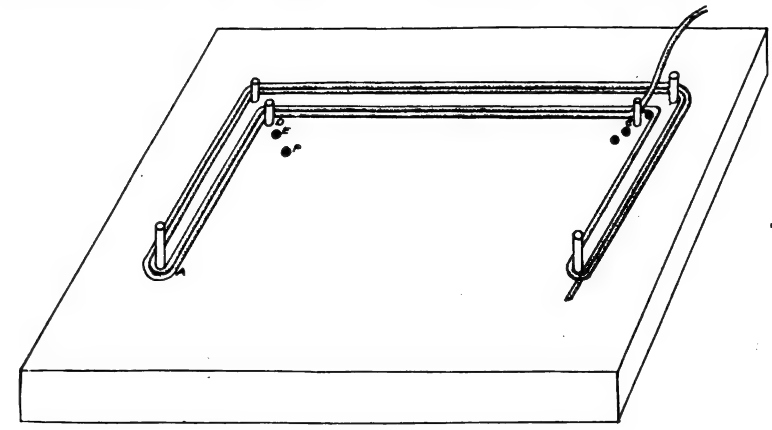


FIG. 3.—EICKEMEYER FORMER.

slot and is, of course, confined by the wire above it. The coils overlap each other much after the fashion of the shingles on a roof, and it is necessary to lift all the intervening wires between the two wires forming the sides of the coil before the latter can be removed. This, however is rather a difficult operation.

Consulting Fig. 1 which indicates the condition of affairs, the conductors, *X* to *A* inclusive, must be lifted clear from their slots before the coil of which *X* forms a side, can be freed. It will also probably be necessary to partially lift the wires, *M* and *N*, for the spiral connectors of these wires interfere with the spiral connector of *A*, as will be seen in the figure, and prevent the latter from being lifted clear from the slot to liberate *Y*.

The position of *Y* is unknown at the start, though it is easy to find *X*. Count the total number of slots on the armature and divide by the number of pole pieces. This will give the number of slots from *X* to *A* inclusive, and, of course, it will be easy, knowing *X*, to count forward to *A*.

Having thus located *A*, unsolder the coil connections at the commutator between *A* and *X* and begin by prying up *N* or *M*, one or two conductors further on, as far as it will conveniently go by means of soft wood wedges. You will be only able to move a very little. Then pass to the next conductor which can then be moved more, and so proceed till *X* is reached. It is probable that *X* can be lifted fully a hand's breadth from the core. If this has been sufficient to lift *A* clear of its slot, the coil may be removed. If not, the operation of progressive lifting must be repeated till *A* is fully clear of its groove. (See Fig. 2.)

If the winding is of the wave type, the coil will not be entirely free even then. The lead that is soldered to one of the commutator lugs will be confined under its fellows, and these must be unsoldered till the lead of the coil to be removed is free. It will not be necessary to lift these additional coils from their slots. The process of inserting a new coil is a precise reversal of the process

already described, and the observing operator having successfully removed a coil, will have no difficulty in replacing it.

The barrel winding, which is becoming very popular in railway work, is the only other winding of this type that the repairman is likely to encounter in electric railway work. This winding is opened on an exactly similar plan and the only difference is that it is a much easier job, as the coils are easily slipped in and out.

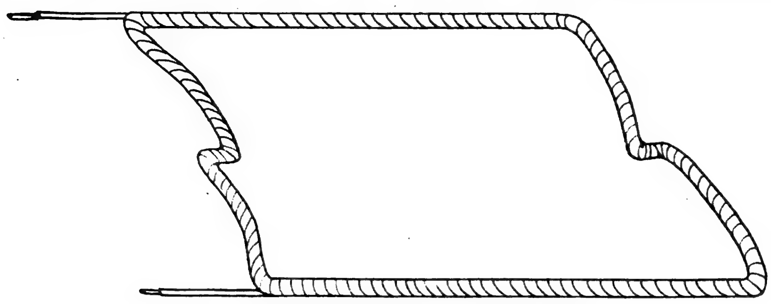


FIG. 4.—EICKEMEYER COIL COMPLETED.

In some few kinds of windings, T-shaped teeth are encountered, and in such cases the wire in the slot must be drawn out from the end and the spiral connector formed up afterward. Oftentimes there is a soldered joint at the end of the slot, and if this is the case, the repair is easier. This is often done in generator construction, but while it admits of easy repair, it is an inferior design.

A few words as to the formation and preparation of the coils may not be amiss. With railway armatures the former are very simple and can be easily made by any one. Nothing is needed with wire-wound coils but a hard wood board of suitable length, a drill, and a few round pins that will fit snugly into the holes that the drill makes. The Eickemeyer former, which is the most difficult, will be described first.

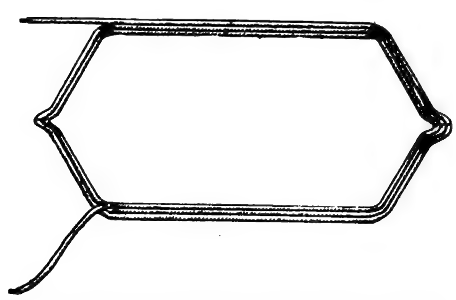


FIG. 6.—BARREL WINDING COIL COMPLETED.

Holes are drilled in the board as shown in Fig. 3, and the distance between these holes must be obtained by suitable measurements of a sample of the coil to be formed. The distance apart of centers of the holes, D, E and F, is equal to the thickness of the insulated wire used. A line drawn through the center of these holes would have an angle of 45 degs. with the lines connecting D and A, and D and C. As the winding progresses, the pins in this row of holes are shifted inward, for on this side of the coil each successive turn comes on the inside of the rectangle, A, D, C, G. With the other half of the coil no such shifting is necessary, as the successive turns come on the outer layers of the rectangle. After the coil is complete—and a few turns suffice—it is spread open and assumes the well known form of Fig. 4. Before spreading it is taped, and if a number of coils are to be made for stock, it will be better to leave them unspread, for that can be as easily done by the winder, who will have to bend them in any event, and it is obvious that the less bending the better. Moreover, the coils pack better in storage just as they come from the former.

When the winding is of the barrel form, it is notably easier to handle. The former consists simply of two pins as in Fig. 5, and the coil can be bent to shape with simple angular bends, as in Fig. 6, for all of its sides are straight. Nothing more than a good pair of pliers is necessary for this work. The proper distance apart of the pins can be ascertained by straightening out an old coil.

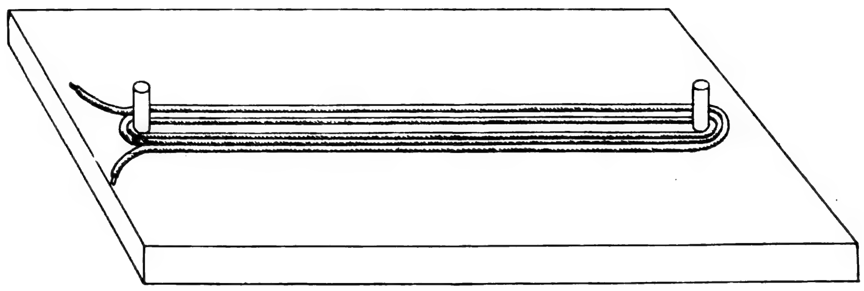


FIG. 5.—BARREL WINDING COIL FORMER.

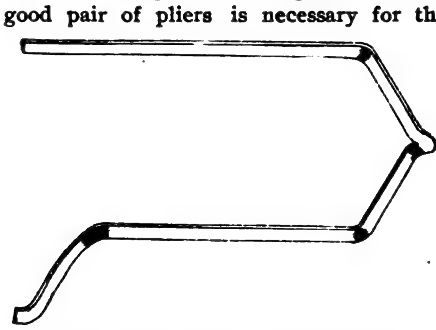


FIG. 8.—RIBBON COIL COMPLETED.

There are now on the market a number of drum-wound armatures on the barrel plan which use narrow ribbons of copper instead of wire, and such coils do not require any former at all. The coil is usually formed as in Fig. 7, and bent to shape with pliers as in Fig. 8. The bend of Fig. 7 is not an easy one to make and requires a special machine; it can, however, be avoided and the same end attained, by bending straight copper ribbon as in Fig. 9. This does not make as neat a job and the end of the coil is more bunchy, but there is always room for it and if the bending is carefully done so as not to develop cracks, it will answer just as well. If a number of ribbons are to be bent, and packed together to form one large ribbon, they had better be bent as in Fig. 10. as they will pack much more closely. These coils are, of course, to be taped before slipping on the core, and for this purpose a tape that is sticky on one side only is best. If the coils are sticky on the outside, great difficulty will be found in adjusting them in place. If this special tape cannot be obtained, it is better to use white cotton tape and thoroughly shellac the completed coil.

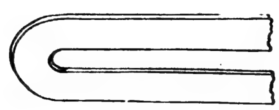


FIG. 7.—FORMING RIBBON COIL—MACHINE BEND.

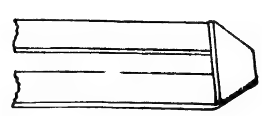


FIG. 9.—FORMING RIBBON COIL—SECOND METHOD.

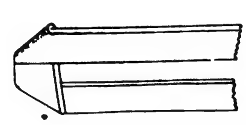


FIG. 10.—FORMING RIBBON COIL—THIRD METHOD.

American Institute of Electrical Engineers.

At the annual March meeting of the American Institute of Electrical Engineers, the following officers were elected: President, Prof. F. B. Crocker; vice-presidents, A. E. Kennelly, Chas. S. Bradley and Prof. Dugald C. Jackson; managers, Prof. Alexander Macfarlane, Gano S. Dunn, W. F. C. Hasson and Herbert Laws Webb. The officers whose terms have not expired are as follows: Vice-presidents, Chas. P. Steinmetz, Prof. Harris J. Ryan and Prof. Wilbur M. Stine; managers, Prof. Wm. L. Puffer, F. A. Pickernell, L. B. Stillwell, John W. Lieb, Jr., B. J. Arnold, Carl Hering, Chas. F. Scott and Dr. Cary T. Hutchinson. It was also decided to hold the general meeting of the Institute at Greenacre-on-the-Piscataqua, Eliot, Me., beginning Monday July 26. This date is the 50th anniversary of the entrance of the late Prof. Moses Gerrish Farmer into the field of electricity, where he labored during the rest of his life. Professor Farmer was one of the charter members of the Institute and in consideration of his high standing as an original investigator and inventor, he was elected an honorary member of the Institute, Oct. 21, 1890. His home during the latter part of his distinguished career was at Eliot, Me., and he died at Chicago May 25, 1893, where he had been engaged in the preparation of his personal exhibit at the World's Fair.

The meeting of the Institute, at Eliot, will be coincident with the holding of a "Greenacre Conference," or course of lectures on electricity.

INTERIOR WIRING.

ALTERNATING-CURRENT APPLIANCES.

There are several pieces of alternating-current apparatus with which the interior wireman should be familiar, not only with their details of construction, but with their combinations and connections.

First of these is the transformer, or converter, as it is sometimes called. It has been shown in previous articles that a small current can be transmitted with a less loss than a large one, other things being equal, and from this consideration it will be apparent that if we can transmit a small current at high pressure, we shall have just as much energy as if we transmitted a proportionally larger current at the working pressure, and we shall effect the transmission with a very much less line loss. Having received this small current at high pressure, it is necessary to transform it into a large current at working pressure, and this is the office of the transformer.

The construction of the transformer is very simple. It consists of two independent coils closely adjacent to each other with a common magnetic circuit. One of the coils consists of many turns of fine wire, and receives the high-voltage current. It thus creates lines of force in the common magnetic circuit, and the other coil, which is of fewer turns of coarser wire, experiences a change of magnetic flux within it, and, consequently, E. M. Fs. are induced within its turns. As there are less turns there will be proportionally less E. M. F. as the resultant of all the turns, and, of course, the number of turns is such that the proper working voltage will be thus produced. The wire of this coil is of larger diameter, and, therefore, more current can be drawn therefrom without overheating the coil. The high-voltage coil is called the primary, and the low-voltage coil is called the secondary, in the case of all transformers that the interior wireman is likely to encounter. To render the statement more complete, it is better to say that the coil that receives the current is called the primary, and the coil that delivers it is called the secondary. That will cover all possible cases, for alternating voltages are sometimes raised by means of a transformer as well as lowered.

It is obvious that we cannot draw out of the transformer any more energy than we put in, and moreover if we begin to draw more current from a transformer than its rating prescribes, the voltage will fall off, even though the attempt to get more current is successful. In short, a transformer when placed on a constant-potential circuit will regulate very like a good shunt dynamo. A transformer is usually indicated in diagram as shown in Fig. 1. The terminals of the secondary, *CD*, must be considered as the sources of supply in an interior wiring system.

From the foregoing the average wireman will readily understand the simple transformer by inspection. He will find on opening the case two light and two heavy terminals. The lighter terminals are those of the primary and are to be connected to the street mains. The heavy terminals are those of the secondary system and are to be connected to the interior-wiring installation.

Unfortunately for simplicity, and fortunately for utility, it is possible to subdivide the coils of a transformer so that by proper connection it can be used on various primary voltages and will deliver secondary currents of different voltages and proportional volumes. These sections are equal in resist-

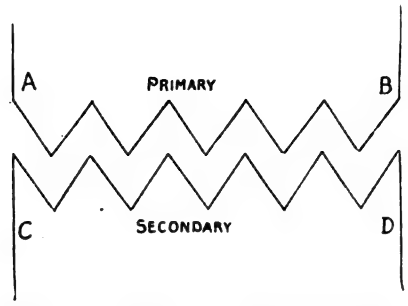


FIG. 1.—DIAGRAM OF TRANSFORMER.

ance and in number of turns, and they may be connected in series or multiple according to the voltage at which they are desired to operate. It is seldom that either the primary or secondary is divided into more than two sections. This would render either coil operative at two voltages, one of which being twice the other. The usual primary voltages are 1100 and 2200, and the usual secondary voltages are 110 and 55. Transformers with a subdivided secondary and a single primary are most common, though not a few have both subdivided primary and secondary, but

order to connect them in series or multiple, as may be desirable. Letter the ends of one coil, *A* and *B*, and the ends of the other, *C* and *D*; connect *B* and *C* together. If there is any difficulty in selecting the ends of two separate coils, place a lamp equal to the total secondary voltage of the transformer across two terminals that are supposed to belong to one coil. If the latter lights up to a dull redness the terminals to which it is connected are the two ends of a section. In this way *A*, *B*, *C* and *D* can be located and marked. With *B* and *C* connected together, apply the free terminals, *A* and *D*, to the terminals of the lamp that is equal in voltage to the higher transformer voltage. If like ends have been connected, the E. M. Fs. of the coils will be equal and opposite and no current will flow, while if unlike ends have been connected the lamp will light up to its full brilliancy, and the coils will be correctly connected in series. Supposing the latter to be the case, take the occasion to tag *A* and *C* "plus" and *B* and *D* "minus," and following these marks, the coils may be connected in series or parallel by the ordinary rules for direct currents.

The same test will suffice to determine the polarity of separate transformers that are to be connected together. If it is not possible to get a lamp that is equal to the combined secondary voltage of the two transformers, two lamps of sufficient voltage may be used in series as the test lamp.

Never attempt to connect in any way two transformers that are not fed from the

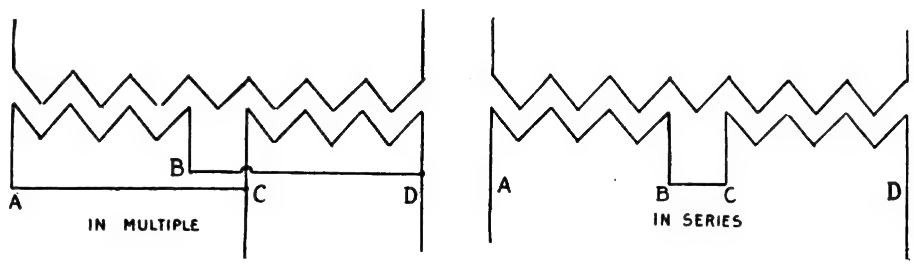


FIG. 2.—CONNECTIONS OF TRANSFORMERS WITH DIVIDED COILS.

a transformer with a subdivided primary and a single secondary is rarely, if ever, met. The conventional way of illustrating transformers with subdivided coils is shown in Fig. 2.

It is hard for a beginner to conceive of a positive or negative terminal in alternating currents, but unless due regard is paid to this particular in connecting sources of alternate-current supply, the effort is liable to result in pyrotechnic disaster. When transformer terminals are marked + or — this means that these terminals are plus or minus at the same time as another set of terminals similarly marked and not that either terminal is continuously plus or minus. Such marks applied to the terminals of a simple transformer are altogether devoid of significance unless another transformer is considered in relation with them.

In some transformers the terminals are so arranged that it is impossible to readily make an error. It is never entirely safe to follow any marks, and it is far better to apply the following simple test: The primary circuits being connected, let it be required to find the instantaneous polarity of the secondary terminals of a pair of sections in

same dynamo. If it should so happen that it be desirable to connect two transformers, and it is not known whether or not their sources of supply are identical, connect their secondaries in series and place across their terminals a pair of lamps, in series also. If they are fed from the same mains they will act as already related, but if they are connected to different sources of supply, the lamp will flicker up to full candle power and down to darkness, in a most erratic manner. This being the case, all further attempts to connect the transformers should be abandoned unless their primary terminals are first connected on to the same mains.

These precautions being borne in mind, transformers can be connected exactly like dynamo machines and will produce analagous results. It is very common to connect transformers in series to operate a three-wire system, and even more a matter of every-day practice to connect them in multiple in order to use their combined capacity on one circuit. A number of transformers connected in multiple is sometimes called a bank.

In connecting primary sections of a transformer, the readiest way is to put in a pair of

the very smallest fuses in the fuse box and try a combination. If it is a proper one, the fuse will not be blown when the transformer is connected on to the line. If it is an improper one and one section demagnetizes what the other magnetizes, the fuse will blow.

It will be easy to detect the series and multiple combinations by inspection. A series combination is used for the high-voltage line (2200 volts) and a multiple combination for the low-voltage one. If a correctly connected multiple combination be connected to a pair of mains operating at the higher voltage, the transformer will hum loudly and the secondary voltage will be nearly double, and the fuse may blow. If the trouble is the connection of a series combination on a low-voltage main (1100 volts), the lamp voltage at the secondary will be one-half what it should be. Be sure that the secondary coils are correctly connected before looking for errors in the primary connections.

It has been stated in a previous article that there are two prevailing frequencies, namely, 7200 and 15000 alternations per minute. The frequency of alternate-current apparatus is usually marked on them. But it might happen that the wireman encounters a transformer about which there are some doubts that could be conveniently cleared up by experiment. If a 7200 transformer be placed on a 15,000 circuit, it will be found that the slightest load lowers the voltage, practically prohibitively. If, on the other hand, a 15,000 transformer is placed on a 7200 circuit, the mistake will be announced by a loud humming noise, and the fuse on the primary circuit may be blown, and certainly will be if it is attempted to load the transformer in the slightest degree. A poorly designed transformer will often emit a humming noise when connected on to the primary mains, but this noise will never be confused with the piercing note emitted by a transformer connected on a circuit of lower frequency or higher voltage than that for which it was designed.

FAULTS IN DIRECT-CURRENT MOTORS.

Faults in motors of any kind are exactly similar to those that occur in generators, but the symptoms indicating their presence are different. When a generator breaks down, it is often impossible to test for the fault through lack of current, and until a magneto or outside source of current is called into play, the investigator must remain uninformed. With a motor, on the other hand, current from the mains is always at hand and can be often profitably used.

Beginning with the simple shunt motor, it is well to say at once that all armature faults are attended by almost exactly similar phenomena as if the motor was run as a dynamo. Any ground or short circuit cutting out or incapacitating some of the armature turns, will be accompanied with a rise in speed of the armature. In fact, a sudden rise in speed that cannot be accounted for, almost invariably indicates a fault.

The usual causes for a rise in speed of a shunt motor are a rise in voltage of the mains; diminished load; adjustment of field or armature rheostat; adjustment of position of brushes.

If a rise in speed occurs without any of these actions operating to cause it, it must be due to diminished number of effective conductors on armature due to ground or short circuit; diminished field excitation, due to poor contact.

Care must be taken to be sure that the fault does not lie in the rheostat adjustments, due to short circuits or grounds therein, before searching for the trouble in the motor.

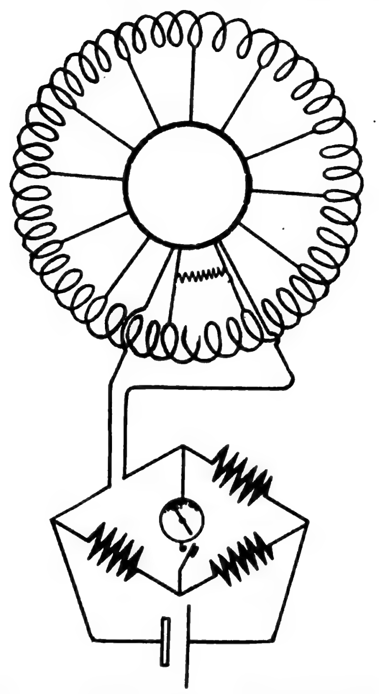


FIG. 1.—APPLICATION OF WHEATSTONE BRIDGE.

Having definitely decided that the fault is in the motor, the next thing is to locate it by the following tests: If the armature is suspected, first feel it all over with the hands.

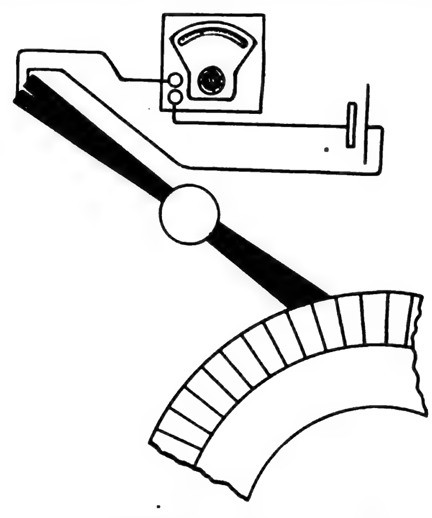


FIG. 2.—SUBSTITUTE FOR WHEATSTONE BRIDGE.

If there be a short-circuited or partially-circuited coil, it will be hotter than its neighbors, and its insulation may be scorched. If the short circuit is a very effective one, the coil will probably be burned out.

If there is no external indication of the short-circuited coil and the fault does not obtain through the medium of one or more grounds, a Wheatstone bridge can be conveniently called into play. Fig. 1 illustrates how this can be done. The bobbins of the armature are always approximately of the same resistance and in modern machines practically exactly so. Therefore the bridge is set to measure the resistance of one bobbin in multiple with the rest of the armature, which latter factor is a very small proportion of the total conductance. Proceed successively from bobbin to bobbin, and when the short-circuited bobbin is reached, a violent deflection will occur.

If the coil is rendered inoperative by a combination of grounds, the test given under faults in dynamos will apply. A substitute for a Wheatstone bridge can be obtained by the use of an ammeter and storage battery if these are at hand.

Set a pair of brushes as in Fig. 2, insulating brush from brush by wrapping with stiff paper. These brushes are adjusted to bear on adjacent segments of the commutator. Place in series the storage cell, the ammeter, and these two brushes, being careful not to allow the current thus obtained to exceed the rated armature current or the capacity of the battery. Turn the armature slowly, and when the short-circuited coil comes under the pair of prepared brushes, the current will largely increase. If the armature is of the old over-wound type, the current will vary as bobbin after bobbin comes under the brushes, due to their different resistances, but there will be no mistake about a short-circuited one. The greater the resistance of the bobbin, the easier it will be to apply this test, which is a very useful one with small motors or motors of high voltage.

Poor contact in the armature circuit often diminishes the voltage at the armature terminals and slows the speed down. The faulty contact gets hot and, of course, is easily detected and repaired. Open circuit in the armature is attended by the same steady flare at the commutator as in the case of a dynamo. The detection and cure is the same.

Open circuit in the field is attended by the entire loss of field magnetism and the instant blowing of the main fuse. A poor contact in the field circuit will increase the speed of the motor notably. Short circuits or grounds in the field coils may or may not alter the strength of the field. If the mean length of a turn of wire is altered, the field will change. If it be made longer, the speed of the motor will increase with the weakened field. If it be made shorter, the speed will diminish. Therefore, if a short circuit is suspected to exist in a field magnet whereby a number of layers are cut out, the resulting variation in the speed of the motor is a clue to the location of the fault. If the speed of the motor is slower, the short circuit must be sought in the outer layers, and if the speed rises, the inner layers are thus cut out. In a shunt field containing a short circuit, the active portions will run much hotter than before the short circuit was applied, while the short-circuited portion itself becomes cold.

In series motors the armature faults are similar to those of shunt motors and similarly found and remedied, but of the field it is necessary to say a few words, for poor contacts and short circuits have different effects. A poor contact, while it weakens the field current, also diminishes the volts available at the armature, and the

effect of the latter will probably prevail. A short circuit in the field will invariably make the motor run faster. When a motor runs faster due to weakening of its field, it usually sparks also and requires some nice adjustment to obtain sparkless commutation.

There are two varieties of the compound motor, in one of which the series coil opposes the shunt coil, making what is called a differential motor while the other has its series coil assisting its shunt coil and is called a cumulative motor. The shunt coil and armature faults have been fully discussed, but a word or two about the series coil will be useful.

The differential series coil if short-circuited, will cause the motor to slow down. If open-circuited, the motor will stop, and if poor contact exists, the motor will slow down on account of diminished armature voltage and strengthened field.

With the cumulative motor a short circuit in the series field coil will speed up the motor and, as with an open circuit or poor contact in that member, the effect of reduced armature voltage will prevail, and the motor will slow down in spite of the fact that its field is weakened.

FLY-WHEEL GOVERNORS.

In the article of last month the effect of varying the throw and the angular advance of the eccentric was shown by valve diagrams, and it will now be appropriate to show how this is accomplished in practice by the fly-wheel governor.

It is easy to see that if the eccentric were loose upon the shaft and connected to the fly-wheel by a system of levers and weights,

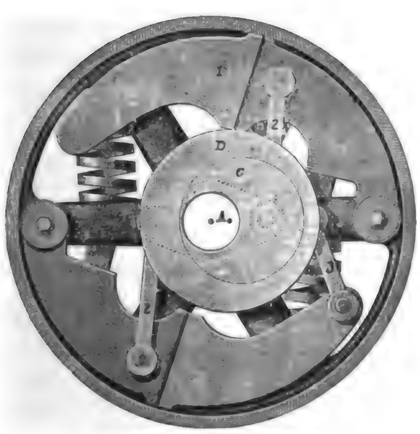


FIG. 1.

that centrifugal force would move the weights and consequently change the angular advance of the eccentric. If the eccentric was made composite, one eccentric turning on another, the relative motion of the two eccentrics could thus be controlled and the combination of these devices would alter both the throw and angular advance, and in a suitably connected governor this motion would take place in such a way as to operate the valve to admit proper amounts of steam for the varying conditions of load.

Fig. 1 shows such an eccentric and governor, which has been in use for a great many years on a well-known engine. The lower weight moves the eccentric, *D*, upon the eccentric, *C*, thus altering the throw of the eccentric as a whole, the angularity being shifting by the action of both weights on C.

This governor operates almost entirely by

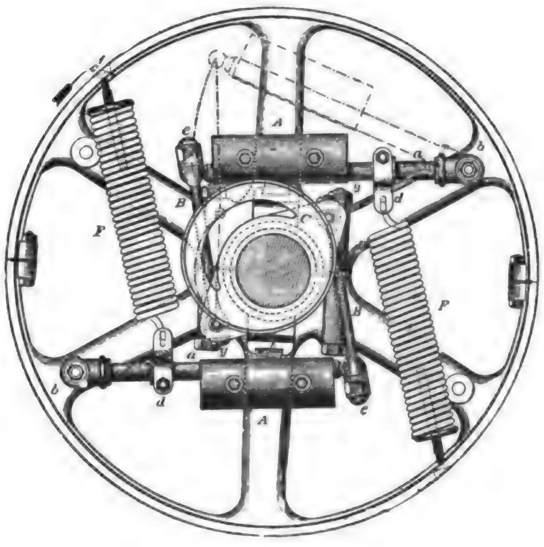


FIG. 3.

centrifugal force. If the speed of the engine falls off when a heavy load is imposed upon it, the springs draw the weights in, increasing the angular advance and the throw, and if the load suddenly comes off, the momentary acceleration of the engine throws the weights out and again regulates the amount of steam admitted.

The same result can be accomplished by a very much simpler and more popular device shown in Fig. 2. In this arrangement there is but one eccentric, which is pivoted by a link at some distance from the center of the main shaft. The hole through which

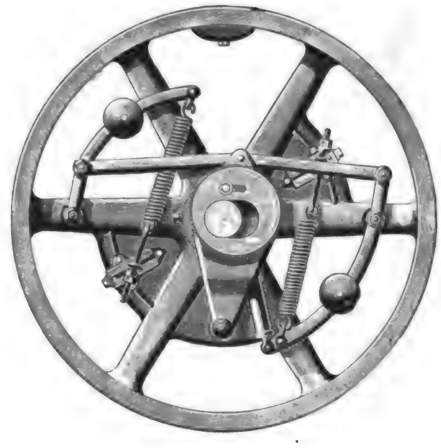


FIG. 2.

the main shaft passes is so shaped as to allow the eccentric to swing back and forth, and this simultaneously alters the throw and the angular advance; it remains therefore to suitably connect this to a system of links, weights and retractile springs. Such a device as this varies the angular advance but very little and mostly affects the throw.

Governors, such as the one shown in Fig. 3, vary the angular advance only, keeping the throw constant, and some, as before stated, use a combination of these motions.

So far the only force operating a governor that has been mentioned is that of centrifugal force, but there is another fully as active and important, and of late years it is being largely used in preference. This force, which is really not a force at all, is the effect of what is commonly called inertia.

Consulting the diagram (Fig. 4), suppose a weight, *A*, to be pivoted at a pin, *P*, on a revolving fly-wheel. If the speed of the fly-wheel changes from any cause—let us say, is slowed down—the weight will travel forward

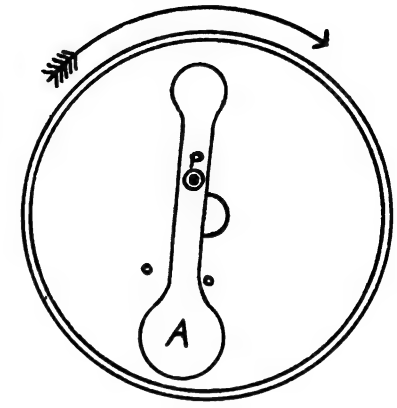


FIG. 4.

by the influence of inertia, and if the fly-wheel suddenly speeds up, the weight will lag behind—in either case moving relatively to the fly-wheel. It is easy to see, therefore, that the weight could be connected by a system of rods or links to an eccentric and vary the throw or the angular advance or both by any devices described.

This device has the great advantage that it operates only while the speed of the engine is changing. With a purely centrifugal governor the weights have a definite position for every speed of the fly-wheel; thus, for example, when the weights fly outward to correct the speed on a sudden release from load, the engine slows down a

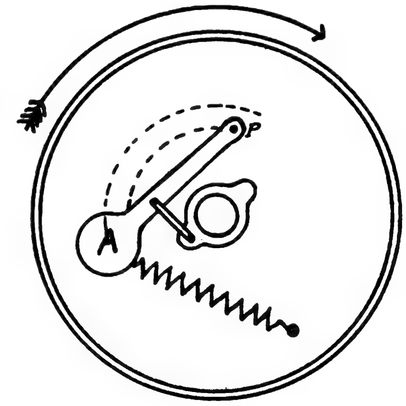


FIG. 5.

little due to their influence, but then the weights tend to return to their former position and the engine will then speed up again, throwing them outward, and thus the governor is always in motion, and the speed of the engine is always slightly varying.

It will be evident at once that if the speed of the engine were absolutely constant and exactly at its rated speed, the position of the governor weights would be absolutely constant and there would be no governing action whatever.

The inertia governor, on the other hand, is not dependent for its position on the speed of the engine. If the speed changes, the governor operates to correct this and remains there until the speed changes again. The action of the inertia governor is also exceedingly prompt. It is usually designed so that centrifugal force plays a part while the engine is starting and to some extent while it is running, but the inertia effect predominates.

An important point in governors of the fly-wheel type should be considered by the purchasers of engines. It has not been appreciated by a great many makers. It is found in the following fact: The weights on any fly-wheel governor are acted upon both by centrifugal force and by inertia, and the governor should be so built that these effects assist each other.

Consider the diagram shown in Fig. 5, which is supposed to represent a centrifugal governor revolving as indicated. If the engine slows down, the spring shown draws the weight, *A*, inward, but the action of inertia on the weight tends to cause it to travel forward, the result of which is to make it move outward. The force of centrifugal force and inertia are here diametrically opposed to each other. The force due to inertia is powerful in the same measure as the change in speed is sudden, and if the change of speed is accomplished instantly, the force of inertia will be infinite and will prevail. Thus, instead of thereby opening the ports it will close them and the engine will slow down still more, until at last the rate of change in speed is so reduced that centrifugal force prevails, and the ports are opened again.

On a sudden release of load, the matter is still worse. The fly-wheel speeds ahead with a sudden jerk and centrifugal force, of course, tends to throw the weight, *A*, outward, but inertia causes it to lag behind and drag inward, thus opening the ports and making the engine run faster. Such an engine would not regulate at all on sudden changes of load, but on gradual changes would operate fairly well.

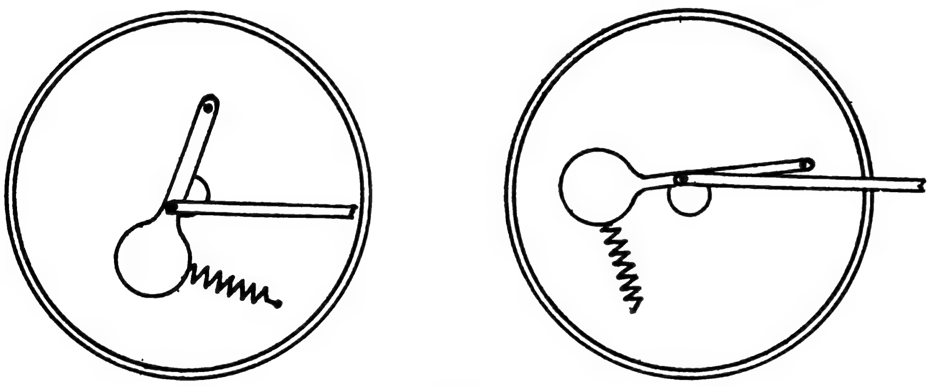
It is easy to see whether or no this action will occur on any governor. If the center of gravity of the running position of the weight, *A*, is in the circle through *P*, described from the centre of the wheel, inertia will oppose centrifugal force and the governor will not regulate on sudden changes of load, provided the pin leads the weight in the rotation.

If the rotation is reversed, the weight leads the pin, and their relative position must be arranged in precisely the reverse way in order that inertia shall aid centrifugal force. That is, the center of gravity of the weight must be outside the circle described by the pin. For this reason it is almost always necessary to reverse the position of the governor weights and pins in order to cause the engine to run in the reverse direction, aside from shifting its angular advance 180 degs. For convenience in this, fly-wheel governors are usually cast with extra bolt holes and pins on the fly-wheel, so that the engine can be readily altered to run in the reverse direction.

If the governor is properly arranged, inertia and centrifugal force will co-operate and the action of the governor will be exceedingly prompt. Whenever the center of gravity of the weight is exactly on the circle of the pin, *P*, inertia will play no part in the action of the governor.

Another important point is the attachment of the valve gear to the eccentric. There are certain positions where a pull or push on the valve rod would very easily move the governor, and there are also others where such pushing or pulling would act like a crank on a dead center and would not move the governor at all. The device should be so designed that when the pull on the valve stem is greatest, the governor should be in the latter position.

Fig. 6 illustrates this principle. It is is obvious that in position *A*, the influence of friction on the valve stem would cause a serious movement of the governor weight,



A FIG. 6. B

the position of which should be dictated by entirely different forces. In position *B*, the great part of the pull of the valve stem comes on the pivot, and the governor should be so designed that this should be the position of maximum motion of the valve. Most of the governors now offered on the market are fairly well designed with respect to these two requirements, but occasionally an engine will be found which by its racing or hunting on sudden changes of load, will indicate that centrifugal force and inertia are not in harmony on its governor, or that the friction of the valve is exerting undue influence.

It is obvious that the forces tending to move the eccentric on the governor should be unimpeded as much as possible, and aside from using the device already mentioned, it is necessary that the valve be wholly or partly balanced and operate with very little friction. A wholly balanced valve is very easy indeed to govern, but has the disadvantage of irregular wearing on its seat and, usually, the impossibility of taking up the wear. In vertical engines where the wear is more symmetrical it has a decided advantage.

The flat valve, as distinguished from the piston valve, is only partly balanced and enough steam pressure remains to press the valve tightly against its seat and automatically take up the wear; this valve, of course, runs much more tightly and while it has the advantage of not leaking, it requires a more powerful and positive governor. It is not always easy to decide which of the two would be best and the matter is a source of considerable engineering warfare between the makers of rival engines.

LESSONS IN PRACTICAL ELECTRICITY

CALCULATION OF WIRING.

Owing to the many requests being received concerning the calculation of electrical conductors—particularly for transmission lines—this article will be devoted to that subject. Following the plan of these lessons, the various practical rules will be built up from fundamental principles, even though at the risk that some of the points considered will be thought needlessly elementary by some readers.

The rational American wire gauge is based upon the circular mil, which is a cross section corresponding to a diameter of one-thousandth of an inch. An advantage of this system is that by it one is enabled to determine very simply, the cross section of a wire if the diameter is known, or its diameter if the cross section is known. For example, if the diameter is one-tenth of an inch or 100 mils (about No. 10 B. & S.) the circular mils are found by squaring this quantity, which gives 10,000 circular mils; or if the section is 26,250 circular mils (No. 6 B. & S.) the diameter is found by extracting the square root of this quantity, which gives 162 mils or .162 in.

The selection of the mil as the unit seems to have been unfortunate owing to its smallness, which may be appreciated from the statement that paper on which this is printed is about 3 mils thick. The smallest wire known to commerce—No. 40 B. & S.—is almost 10 mils in diameter. If the one-hundredth of an inch had instead been used, the numbers would be much more convenient. In this case the cross-section of a No. 30 wire would be 1 circular unit, that of a No. 10 wire 103.8 circular units and of a No. 4-0 wire 2116 circular units, while a cable of 5,000,000 circular mils would become to 50,000 circular units. It would, perhaps, have been difficult to have found a name for the unit as suitable in length and sound as the corresponding one of "mil," but this would have been a small matter.

The Brown & Sharp wire gauge is based upon the logarithmic curve, but is practically an arbitrary system. It has, however, one valuable property, which is that the cross-section is almost exactly doubled every third number. That is, the cross-sec-

tion of a No. 2. wire is double that of a No. 5 wire and therefore its resistance is half that of the latter; or the cross-section is one-half that of a No. 2-0 wire and its resistance therefore twice greater. It happens that the diameter of a No. 10 wire is almost exactly $\frac{1}{10}$ in. or 100 mils, and its resistance about one ohm per 1000 ft. By bearing these easily remembered numbers in mind the cross-section and resistance of other wires on the B. & S. scale at intervals of three numbers on either side may almost instantly be known. Assuming the cross-section to be 10,000 circular mils 100 (mils) $\times$ 100 (mils), the cross-section of a No. 7 wire is 20,000 mils, of a No. 4 wire 40,000 mils, of a No. 1 wire 80,000 mils, of a No. 3-0 wire 160,000 mils, etc.; the resistances per 1000 ft. being ½, ¼, ⅓ and $\frac{1}{16}$ ohm, respectively. Similarly, the cross-section of No. 13, 16, 19 and 22 wire are 5000, 2500, 1250, and 625 circular mils, respectively; and 2, 4, 8 and 16 ohms, respectively. The above figures are not exact, the cross-section of a No. 3-0 wire being, for example, 167,800 instead of 160,000 mils, but they are sufficiently close for purposes for which such a short-cut method would be used.

The formulas for calculating the sizes of conductors are most simply built up if the basis is made the resistance of a mil-foot of wire; that is, the resistance of an assumed wire one foot long, having a diameter of one mil and consequently a cross section of one circular mil.

In order to deduce this value we must know the specific resistance or *resistivity* of conductors. This is given for all the various conductive materials in tables that may be found in text-books and elsewhere. After having made the necessary corrections to the quantity found in such a table for temperature and percentage purity, we have for the value of copper about 1760, which is the resistance of a piece of copper one centimetre long having a cross-section of one square centimetre.

By referring to a table of metric equivalents, it will be found that a square centimetre contains 197,400 circular mils; therefore, the resistance of a wire one centimetre long, but having a cross-section of one circular mil will be 197,400 $\times$ 1760 units. Also, since a foot contains 30.48 centimetres, if the length were a foot instead of a centimetre, the resistance would again be increased, and now become 197,400 $\times$ 1760 $\times$ 30.48. But an ohm contains 100,000,000 absolute units of resistance, so to reduce to ohms the above product must be divided by this quantity. Performing the multiplication and division, we have, finally, 10.6 ohms to be the resistance of one foot of wire of one circular mil cross-section.

By carrying this useful constant in the memory, and remembering the data given above for a No. 10 wire, one can be independent of wire tables and formulas for approximate calculations.

For example, suppose it is required to know the size of wire to carry 50 amperes 200 ft. with a drop of 5 per cent., the voltage being 125. The drop will thus be .05 $\times$ 125 = 6.25 volts, and from Ohm's law $R = \frac{E}{C}$, we find the resistance to be 6.25 $\div$ 50 = .125 ohm. As the distance is 200 ft., 400 ft. of wire will be required. The resistance of 400 mil-ft. of wire is 10.6 $\times$ 400 = 4240 ohms; as the actual resistance of the line in question, is, however, only .125 ohm, the size of the wire that will have this resistance will be in the proportion of 4240 : .125; the quotient of the former by the latter is 33,920, or the required cross-section of wire is 33,920 circular mils. Now, as shown before, the cross-section of No. 10 wire being 10,000 circular mils, that of No. 7 is 20,000 circular mils, and of No. 4 40,000 circular mils. Dividing the difference between No. 4 and No. 7 wire, or 20,000, into three parts, we have 27,000 and 34,000 as rough approximations to the cross-sections of No. 5 and No. 6 wire, and it is at once seen that No. 6 is the nearest gauge number to the required size of wire.

The above operation may be expressed in the following rule:

1°. From Ohm's law, $R = \frac{E}{C}$, where E is the drop in volts, and C the current to be carried, find the resistance, R, of the circuit. 2°. Multiply the length of conductor in circuit in feet by 10.6. 3°. Divide 1° by 2°, which gives the circular mils of cross-section in required conductor.

The above rule is very simply expressed in the formula,

$$\text{circ. mils} = \frac{21.2\, L\, C}{p\, E}, \qquad (1)$$

where L is the length of line, C the current, E the voltage, and p the percentage drop. The formula may be put in the more satisfactory form

$$\text{circ. mils} = \frac{2120\, L\, C}{p\, V}, \qquad (2)$$

where V is the line voltage and p is expressed as an integer instead of a decimal—as 5, for example, instead of .05, when the drop is 5 per cent. Applying the data of the problem solved approximately above, we have

$$\text{circ. mils} = \frac{2120 \times 200 \times 50}{5 \times 125} = 33{,}920.$$

Suppose we wish a formula for wiring incandescent lamps, in which the number of lamps and not the current enters. In this case we will represent the number of watts to each lamp by W, and if the number of lamps is N, the total watts are $N \times W$. Since the watts are also the product of the E. M. F. by the current (CE), the current is $\frac{N\, W}{E}$; substituting this in formula (2) for C, we have

$$\text{circ. mils} = \frac{2120\, W\, L\, N}{p\, E^2}. \qquad (3)$$

If lamps are distributed along the circuit to be calculated, the distance, L, will be the distance to the center of all the lights and not the total length of the line. As an example, suppose there are 50 lamps of 3½ watts per CP or 56 watts per lamp, the voltage being 110, the drop 3 per cent. and the distance to center of lights 100 ft. We thus have

$$\text{circ. mils} = \frac{2120 \times 56 \times 100 \times 50}{3 \times 110 \times 110} = 16{,}352,$$

which is equivalent to No. 8 B. & S. wire. By means of formula (3) the usual tables for lamp wiring may be computed.

In interior wiring, it is always necessary to see that the size of wire calculated is large enough for underwriters' requirements with respect to heating, or, as it is sometimes called, carrying capacity. Since the watts per lamp in this case are 56 and the voltage 110, the current for each lamp is 56 $\div$ 110 amperes, or 50 (56 $\div$ 110) or 25.4 amperes for 50 lamps. As the underwriters' rules allow (or did allow) 25 amperes for No. 8 wire, the size calculated for drop will just pass muster. For lines of considerable length the heating limit cuts no figure, owing to the more considerable section it is necessary to provide the conductor for a given current in order to keep down the drop.

The above formulas are all that are necessary for any wiring calculations based upon considerations of simple drop alone, applying equally to direct currents and to alternating currents, both single and polyphased. With polyphased currents, however, allowance must be made for the increased copper economy entailed by their use, which amounts to 25 per cent. in the three-phased system. This may most simply be done by using formula (1), and then for each wire in the three-phased system (which system will probably always alone apply to transmission lines), take half the size of the wire calculated by that formula. The reason for this may be illustrated as follows:

Suppose from formula (1) we find the cross section with the given data to be 100,000 circular mils, on the basis of a two-wire, continuous-current system; the cross-sections of both conductors will thus be 200,000 circular mils. Since, however, the three-phased system only takes three-fourths as much copper as the continuous-current system, this cross-section is reduced to 150,000 circular mils, and there being three wires, each will have a cross-section of 50,000 circular mils, or half that of each of the two conductors in the continuous-current system.

Having found the section in this manner of the conductors of a three-wire system, allowance must must next be made for idle current due to the inductance of the motor load. Suppose the load factor to be .95, which means that of the entire current passing over the line, only .95 is effective. In order to keep the drop the same, the cross-section will have to be increased in the proportion of 1 : .95; or, dividing 50,000 by .95, we have 52,632 circular mils. The factor .95 might instead have been introduced in the formula by increasing the amperes in the ratio of 1 : .95, which is the usual method.

The caution should here be given that the calculation of long lines for the transmission of considerable quantities of electrical energy is not made in the simple way here indicated, for reasons given in another column. Nor does the method take into consideration drop due to inductance, which is a quantity depending, as shown in previous articles, upon the amount of current carried and the distance apart and relative disposition of the line wires; this drop may, however, be practically counterbalanced by the use of over-excited motors at the receiving end of the line. The method, nevertheless, may be made to answer for rough preliminary estimates of copper required, and will be here applied to answer the query of a correspondent, who asks the cost of copper to transmit 1000 HP 30 miles. The calculation is made for the three-phased system and a drop of 10 per cent., a load factor of .95

and at a cost of 12 cents per pound for copper, the voltage being assumed 10,000.

As the drop is 10 per cent. and the voltage of delivery is 10,000, the original voltage must be in the proportion of 1 : .9, or 11,111 volts, or the drop is 11,111—10,000 = 1111 volts. In 1000 HP there are 746×1000 watts (CE); the current is therefore $746,000 \div 10,000 = 74.6$ amperes, which being increased in the proportion of 1 : .95 by the load factor, becomes 78.6 amperes.

The length in feet of 30 miles is 158,400, and substituting in formula (1), $C = 78.6$, $L = 158,400$ and $p\,E = 1111$, we have for the size of each of two conductors

$$\frac{21.2 \times 78.6 \times 158,400}{1111} = 237,400 \text{ circ. mils.}$$

The cross-section of each conductor in the three-wire system, being one-half of this, is 118,700 circular mils, or somewhat larger than No. 0 wire. The weight per foot of 4-0 bare copper wire is .64 lbs., and as the cross-section of 4-0 wire is 211,600 circular mils, the calculated wire will weigh $\frac{118,700}{211,600} \times .64$ lbs. per foot. The 90 miles of conductor ($90 \times 5280 = 475,200$ ft.) will therefore weigh

$$\frac{118,700 \times 475,200}{211,600} \times .64 = 200,100 \text{ lbs.}$$

At 12 cents per pound, the cost of this will be $24,012. Supposing that there are 50 poles to the mile, costing set, $6 each including insulators and cost of stringing wires, the total cost of pole line becomes about $31,000 or $31 per horse power. As the water power development and cost of generating plant and transformers might easily amount to much over $100,000, it will be seen that usually it is not necessary to go into the cost of the copper to determine the feasibility of a transmission scheme.

THE HORSE POWER.

In the course of a "Watt Anniversary Lecture" delivered at Greenock, Scotland, Mr. W. H. Preece, engineer-in-chief and electrician of the British telegraph and telephone service, strongly advocated the displacement of the horse power by the kilowatt as the unit of power or activity. In referring to the origin of the present value of the horse power, he stated that when Watt introduced the steam engine, the chief competitor to be met was the horse. "It worked the pumps in mines and brewhouses. It drew the ores to the surface. It was employed for grinding and for milling. It was clear that his customers would compare the performance of his engines with that of their horses. He determined by experiment that a good horse working continuously, could raise 22,000 lbs. 1 ft. high in one minute. He thought he would go 'one better'; so he said, 'I will call 33,000 lbs. raised 1 ft. high in one minute a horse's power.' Thus he gave his customers the advantage of 50 per cent. more work; he showed moreover that, in Whitbread's brewhouse, his engine 'does the work for which thirty strong horses were kept, and consumed $\frac{5}{16}$ bushel of coals per hour.'"

Mr. Preece stated that James Watt was not the first to use the term "horse's power." Savery did this in 1702. "An engine," said Savery, "which will raise as much water as two horses working together at one time in such a work, can do, and for which there must be constantly kept ten or twelve horses for doing the same, then I say such an engine will do the work or labor of ten or twelve horses." Watt, however, gave the unit a scientific character and was virtually its founder. Smeaton also anticipated Watt, in 1759 having laid down the principle that "the raising of a weight relative to the height to which it can be raised in a given time is the most proper measure of power."

The definition given by Watt to horse power was, Mr. Preece considers, singularly unfortunate. "It means fifteen tons moved at a snail's pace. Few people can grasp the conception. We know what a man can do, especially when rowing a race or when raising bricks. Going up a mountain at the rate of 1000 ft. per hour—a fair performance—he does about $\frac{1}{13}$ of a horse's power if he weighs twelve stone. Working a treadmill absorbs $\frac{1}{8}$ HP, which is distinctly hard labor. If he runs upstairs at the rate of $3\frac{1}{4}$ ft. per second he does 1 HP; and this is not good for his heart. We also know what a horse can do in drawing a cart or moving a canal barge. '550 lbs. moved 1 ft. per second'—the leisurely pace of a child walking—is more comprehensible than, and the same thing as, 33,000 ft. lbs. per minute, and is now more frequently used, especially abroad."

In answer to the question, Is a horse power really a horse's power? Mr. Preece stated that Tredgold found its value to be 27,000 ft. lbs. per minute for eight hours. Rennie assumed 22,000 as correct. Beardmore had a horse weighing a little over half a ton which did 39,000 ft. lbs. per minute eight hours a day. Morin made it 26,150 ft. lbs. Two horses will tow a canal boat at $2\frac{1}{2}$ miles an hour, while a steam engine of 10 HP, is needed to do the same work by means of a screw. Tram cars are drawn by two horses at a speed which the so-called 25-HP motor can scarcely do. The horse is really a more efficient machine for a time than the engine, and at times expends more energy than the so-called horse power.

As to the origin of the term "watt," it was applied in 1883 by the late Sir William Siemens to designate the joule per second, but Mr. Preece had previously, in 1881, at the Paris Congress, proposed to apply it to 1000 joules per second. Siemens' proposal has been preferred, and in consequence the practical unit of power comparable with the horse power became the *kilowatt*, equivalent to 1.34, or almost exactly $1\frac{1}{3}$ HP. Had Mr. Preece's proposal found favor, the practical unit of power would have been the watt, and Siemens' unit would have been a milliwatt, and the lecturer very truly remarked that the acceptance of his unit would have hastened the departure of the term horse power.

INTERCOMMUNICATING TELEPHONE SYSTEM.

In response to several inquiries, the accompanying diagram of a simple intercommunicating telephone system is printed, together with a diagram of connections in a telephone case, both for a battery and a magneto call system.

The diagrams so clearly indicate the principles involved as to require little or no explanation. It will be seen that for No. 1 to call No. 3 he merely moves the switch of

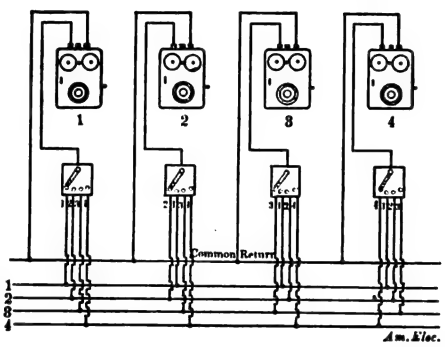


FIG. 1.—DIAGRAM OF LINE CONNECTIONS.

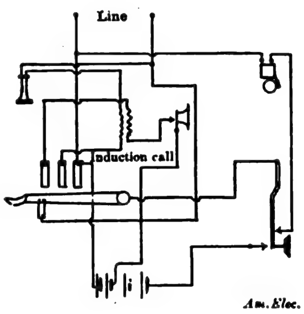


FIG. 2.—CONNECTIONS OF BATTERY TELEPHONE.

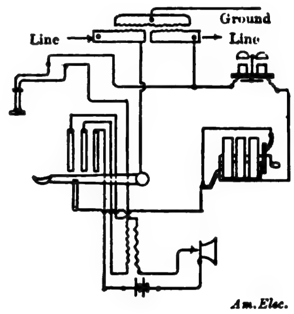


FIG. 3.—CONNECTIONS OF MAGNETO TELEPHONE.

his lever to the point marked 3, and touches the call button. The switch lever of each station is normally kept on the point corresponding to the number of the station.

The Davy-Faraday Research Laboratory.

Dr. Ludwig Mond, the founder of the Davy-Faraday research laboratory recently opened at London, has expended half a million dollars for the building, equipment and endowment proper of the institution which he has presented to the British nation. The control has been given to the Royal Institution, and Lord Rayleigh and Professor Dewar have been appointed its directors. The laboratory is open to all, irrespective of sex or nationality, who have either already done original scientific work or have been judged qualified by the Laboratory Commission to prosecute original research in pure or physical chemistry. The five-story building contains rooms for research in organic, inorganic and physical chemistry, for electrical and photographic work, besides a large library, a museum of apparatus, the secretary's office and cloakroom. In the basement are the laboratories for pyro-, and thermo chemistry and electricity, a battery of accumulators, constant temperature vaults and boiler rooms.

Electrical Catechism

109. How do alternators differ from direct current generators?

Principally in the fact that the alternator does not necessarily have a commutator, while the direct-current generator always requires a commutator unless for very low voltages. By the omission of the commutator, the armature gives an alternating instead of a direct current.

110. How is the current taken from the alternator if there is no commutator?

The two ends of the armature winding are connected to two smooth rings, called collecting rings, upon which brushes make contact. In some machines the armature is stationary and the ends of the armature winding are connected directly with the terminals of the machine.

111. Would a direct-current dynamo give an alternating current if collecting rings were substituted for the commutator?

It would if means were provided for keeping up the magnetic field. (See No. 106. American Electrician, Mar., 1897, page 103.) But this would not be the most economical winding for an alternator, and a machine built for alternating currents would be wound differently from a direct-current machine.

112. How does the winding of an alternator armature differ from that of a direct-current machine?

In direct-current machines, except "open coil" arc light dynamos, the armatures are wound with a large number of separate coils connected in series and arranged so that the electromotive force being generated in the different coils at any instant varies from almost zero in the coils connected with the commutator bars under the brushes to a maximum value in the coils midway between the brushes. The sum of the E. M. Fs. in all the coils of a direct current machine, is nearly constant from instant to instant, although the E. M. F. in any one coil varies from zero to the maximum as many times in each revolution of the armature as there are poles in the field. In the alternator armature, the coils are arranged so that the E. M. Fs. in all the coils reach corresponding values at the same time, all being at zero at the same time and all being at the highest at the same time. In other words, all the coils on an alternator armature act as one coil and the total E. M. F. of the armature at any instant is the E. M. F. of one coil multiplied by the number of coils. If the alternator field had only one pair of poles, there would be only one coil as in the magneto. In a multipolar alternator for single-phase currents the number of armature coils is equal to or is one-half of the number of poles.

113. How many poles do alternators have?

Small magneto machines for telephone signals and testing have only two poles. Larger generators for light and power have from ten to sixty or more poles.

114. Why do alternators have so many poles?

In order to get high frequency without excessive speed of armature. The alternating currents used practically make from 3000 to 16,800 reversals per minute, or make from 25 to 140 complete cycles per second, the more common practice being between 60 and 138 cycles per second.

115. What limits the frequency of alternating currents?

The lower limit is governed by the use made of the current. Unless the frequency is as high as about 40 cycles per second, arc lamps would not burn well and incandescent lights would flicker. High frequencies were used when alternating currents were first introduced in order to allow transformers to be made small and cheap for a given output to compete with low-voltage direct-current systems. But with the high frequency it is more difficult to operate motors satisfactorily, and the difficulties from induction on the circuits increase. The recent tendency seems to be toward a frequency of 60 or 72 cycles per second. For certain experimental work, frequencies running up into the thousands per second have been used, but these have not yet reached the commercial stage.

116. What is a two-phase current?

By a two-phase current is meant two separate alternating currents which are maintained at a constant difference of phase. These currents are 90 degs. apart, one current being at its maximum value when the other is at its zero value. This is illustrated in Fig. 1, in which the solid curve, *B*, represents one current and the dotted

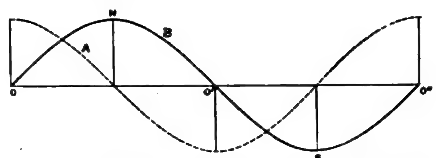


FIG. 1.—CURVES OF TWO-PHASE CURRENTS.

curve, *A*, the other, the value of the current at any instant being represented by its distance above or below the straight horizontal line, the distance from o to o″ representing the time required for a complete cycle. Each current is usually carried on its own circuit independent of the other.

117. How are two-phase currents obtained?

One way is by the use of four collecting rings connected with four points on a direct-current commutator, one pair being connected to points directly under brushes of opposite polarity, the other pair being connected to points midway between these. Another method is to couple the armature shafts of two similar alternator armatures together so that the E. M. F. of one is a maximum at the same instant that the E. M. F. of the other is at zero. The more usual method for commercial work is to use a regular two-phase alternator.

118. What is a two-phase alternator?

A two-phase alternator has two separate windings which are so arranged that the E. M. F. in one is zero at the instant when the E. M. F. of the other is at a maximum. This is illustrated diagrammatically in Fig. 2, which represents a two-pole machine with two coils at right angles. In the sketch shown, the coil, *A*, is at the position of zero E. M. F., while coil *B* is in the position of greatest E. M. F. In the actual two-phase alternators there are, of course, more poles

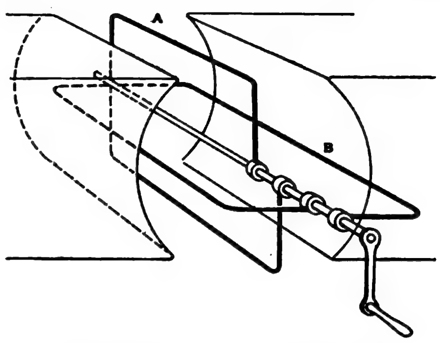


FIG. 2.—DIAGRAM OF TWO-PHASE ALTERNATOR.

and more coils in each circuit, the two sets being arranged so that the coils of one set are between the poles when the others are under them.

119. What is a three-phase current?

A so-called three-phase current consists of three separate currents in three separate circuits, the three being 120 electrical degs. apart as illustrated in Fig. 3. If the time or distance from o to o″ be considered as divided into 360 degs. representing an entire circle or cycle, corresponding values of the three currents are 120 degs. apart.

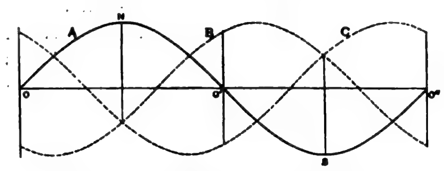


FIG. 3.—CURVES OF THREE-PHASE CURRENTS.

120. How are three-phase currents obtained?

By collecting rings coupled to points on a direct-current generator 120 degs. apart, considering the distance from a positive to a negative brush on the commutator as being 180 degs. or one-half cycle. Also three single-phase alternator armatures may have their shafts mechanically coupled. Regular three-phase alternators have three distinct armature windings equally distant, as suggested in Fig. 4, which like Fig. 2, illustrates an ideal form with only two poles.

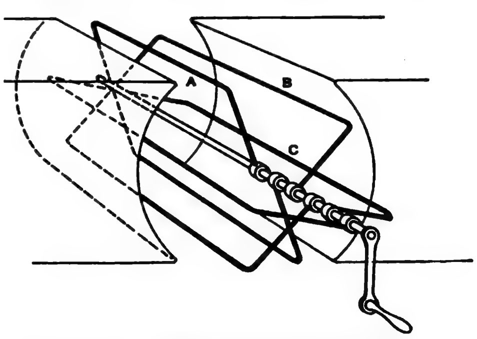


FIG. 4.—DIAGRAM OF THREE-PHASE ALTERNATOR.

Letters on Practical Subjects

Equalizer on Polyphased Generators.

To the Editor of American Electrician:

I have been interested in reading the reply to the query of "Graduate," in your March number. In further answer thereto I would state that we have been running two 100-KW G. E. tri-phase machines, compound wound, for nearly a year *without* an equalizing connection. These machines are in separate stations nearly 4 miles apart, are over-compounded for about 10 per cent. and are run regularly in this manner. We operate at 2300 volts over three No. 6 B. & S. wires and distribute energy for lighting at both ends of the line. Our stations are operated by water, with a steam auxiliary when needed.

Seneca Falls, N. Y. N. T. WILCOX.

Heating of Fuses and Lowering Voltage of a Dynamo.

To the Editor of American Electrician:

In a query in the March issue, J. M. Q. asks the cause of fuses burning out on the main circuit of a 65-ampere, 110-volt dynamo. He states that the fuse-box is just above the main switch, and though fused with wire marked 100 amperes, it heats badly and sometimes blows. While the trouble may be due to the fuse being wrongly rated, it would be well for him to look for defective insulation in his wiring, determine if his machine has not a heavier load than he is aware of, and see that there is not a poor connection at his fuse block which causes heating.

The same query asks in regard to cutting down the voltage of a dynamo. While the case is not the same since the load is constant and regulation is not involved, I may say that I am running a 125-volt dynamo at normal speed for charging a storage battery, but with the voltage cut down to 65 volts by inserting resistance in the field. I am using a Wirt brush having a high resistance, heel and toe, which suppresses any tendency to sparking.

Lawrence, Mass. JAS. C. RAMSEY.

Sparking Commutators.

To the Editor of American Electrician:

The following experience with a sparking street railway motor may be of interest to your readers. I had my attention called by a car shed superintendent to a commutator that would eat up a set of brushes in eight hours. The machine to which it belonged was a Westinghouse No. 3 motor, single reduction, and had run four years with the same commutator. On the occasion referred to, we ran the car out of the barn, and both brushes sparked furiously; we stopped and cleaned the commutator (which was perfectly true, having been turned off the day before), but with no better result. I then examined the commutator carefully, and found that it had been turned off about an inch from the original size, and the brush holders moved down to the commutator. Counting the bars between the brushes (which should have been twenty-four, counting the bars under the brush), it was found that there were but nineteen and one-half. The car was then run over the pit, the shield taken off and the bolts loosened holding the brush studs; an equal number of cardboard liners were put in on both studs until there were twenty-four bars between the brushes (counting those under the brushes). When the shield was put on and a trial run made the brushes ran sparkless.

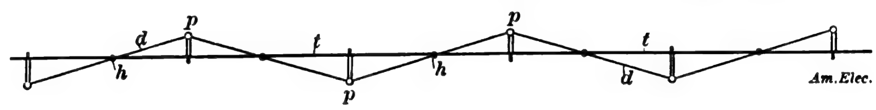
H. S. HALL.

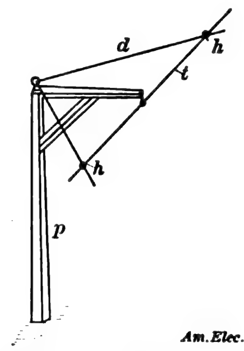
New York, N. Y.

A Cheap Trolley Line Construction.

To the Editor of American Electrician:

Recently I have been making an estimate on the cost of constructing a long electric railway in the mountains. In scheming to cut down the expense, it occurred to me that





a very considerable saving could be made by using a slight modification of our previously described diagonal methods of support.

The plan shown in the accompanying sketch requires but one quarter of the number of poles that the ordinary span construction does, or but one-half the number required by the bracket construction. In addition, the span wires may serve as feeders and also act as stays for such pull-offs as may be required on long curves. The span has other advantages, among them the liability of the poles being broken down by land slides, falling rocks, runaway teams, etc., is reduced in proportion to their number.

In the accompanying sketch, *p*, represents the ordinary bracket pole, *t*, the trolley wire, *d*, the diagonal span wire and feeder, and *h*, an insulating hanger.

Denver, Col. JNO. C. HENRY.

How to Make a Commutator Carbon Brush.

To the Editor of American Electrician:

There are a great many motors and small dynamos using copper brushes where carbon ones would be preferred, but cannot be directly substituted owing to the form of brush holder. One way out of the difficulty is as follows:

Take some sheet brass about $\frac{1}{16}$ in. thick, and cut in the form of a letter T, the width of all parts to be the same as of the copper brush. The top projections of the T should be long enough to wrap around a piece of copper-coated carbon the same width as the brush and as long as is possible between the holder and commutator. Bend the ends around an iron form the same size as the carbon, and then solder the carbons in the little boxes thus made on the ends. A carbon brush made in this manner will fit the brush holder. After the carbons are worn out, heat them, knock out the old pieces and replace with new, the same as before. When the change is made from copper to carbon, the commutator must be turned off smooth. In this way old commutators may be made to last a good many years. In putting the fresh brush on the commutator, cut a strip of sandpaper the width of the commutator, lay this on the commutator with the sand side out, then let the brushes come down on it and draw the paper back and forth until the butting ends fit the surface of the commutator.

S. M. COLEMAN.

San Francisco, Cal.

Alternators in Parallel.

To the Editor of American Electrician:

I have read with considerable interest the query of "Graduate" in your February number, and the answers thereto in the March number. One important principle in the operation of alternators in parallel does not seem to be appreciated by either of those answering "Graduate's" questions.

Neither wave form, field excitation nor any other *electrical* condition can have any effect on the division of load between two alternators running in parallel. The electrical energy delivered by an alternator is equal to the mechanical energy put in, less the loss in the alternator, and the amount of energy put in depends solely upon the valve opening of the engine or water wheel, as the case may be. It is evident that the amount of this valve opening is independent of any electrical condition when alternators are running in parallel, because the alternators must run in synchronism, and a change in the speed of one necessitates a change in the speed of the others. Adjustment of the governor is the only way to shift the load from one alternator to another.

It is rather confusing for one who has been used to running direct-current machines in parallel, where all the adjustment of loads is accomplished by adjusting field strengths, to accommodate himself to the idea that the adjustment of the field has no influence in dividing the loads of alternators running in parallel, but if he will stop to consider it a few moments, he will find it to be the case.

The above, of course, refers to the real output of alternators and not to the apparent output. In order to give a certain E. M. F., an alternator must have a given amount of magnetizing effect, and if it does not get that magnetizing effect from its field, it must draw it from its own armature in the form of an armature reaction, which assists the field. This condition means an exchange of idle current between the armatures, the amount depending upon the difference in field excitation.

PAUL M. LINCOLN.

Niagara Falls, N. Y.

QUERIES AND ANSWERS

Will it injure a phonograph motor (taking 4 amperes) to connect it to a 110-volt circuit, using incandescent lamps as resistances? P. P. L.

No. Use eight 16-CP lamps in parallel or their equivalent in lamps of higher candle-power.

Having access to a 500-volt circuit, how shall I proceed to magnetize a pair of magnets for a magneto machine? D. H.

Wind the limbs with fine wire (up to No. 30 B. & S.) and connect to the 500-volt circuit, with five 110-volt lamps in series. If you have an old electro-magnet, use the wire of its windings.

1°. What are the data of an induction coil suitable for use with a telephone transmitter on a line four or five hundred miles long? 2°. What kind of transmitter is best adapted for this service? T. B.

1°. A secondary coil of about 17 ohms resistance made of No. 30 B. & S. single silk-covered wire; a primary of one-half ohm resistance and No. 16 single cotton-covered wire. 2°. A solid back Hunnings type.

Why should a constant-current dynamo running free tend to race more than a series dynamo running free on a constant potential circuit? O. F. L.

Because the latter reaches a limit of speed when its counter E. M. F. becomes equal to the voltage of the constant-potential circuit; in the case of the former, the E. M. F at the binding post will "follow up" the counter E. M. F.

1°. What voltage is required to produce an inch spark from an induction coil? 2°. What fraction of an ampere is most desirable for Röntgen ray work? 3°. What voltage and amperage is needed for the coil described in the January issue? D. C. C.

1°. See answer to J. J. S. 2°. The amperage corresponding to a spark of 3 ins. or greater. 3°. About 50 watts, or 4 amperes and 10 volts. See editorial on the primary of induction coils in January number.

What should be the windings of the dynamo of which I send drawings of field frame and armature. J. G. F.

The machine is improperly designed and cannot be made to work as a dynamo and will not give any power as a motor; the field magnet cores are not more than half the size they should be if of wrought iron, and one-fourth the proper size if of cast iron. The machine described in our February number will give the output desired.

Can an induction coil be designed mathematically? D. C. C.

Not with present knowledge, owing principally to the indefinite nature of the magnetic circuit and to secondary leakage. It has been found, for example, that by stripping wire from the interior of secondary coils of old design, thereby increasing the space between primary and secondary by half the depth of the latter or more, the length of spark may be increased, though the amount of wire in the secondary be reduced 50 per cent.

What would be the dimensions of a horse-shoe permanent magnet to carry 125 lbs.? W. R.

No data can be found on this subject, and besides, the quality of steel is a determining factor. As the magnet should be compound—that is, composed of a number of similar magnets—make an ordinary 6 in. magnet and then find how many will be needed to support the given weight. By arming the ends of the magnets with a piece of soft iron tapering so as to reduce the polar area, the portative power will be increased.

Will the readings of continuous-current voltmeters in series and ammeters in parallel be accurate? O. F. L.

Yes. In the first case, assuming two instruments in series, one voltmeter will measure the potential difference between a terminal and its connection to the other voltmeter, and the latter the P. D. between this point and the other terminal, the sum being the entire voltage; if the resistance of one voltmeter is twice that of the other, its reading will be twice as great, but the sum of the two readings will be correct. In the case of the ammeters, the current will be divided into portions and each measured. On alternating-current circuits the sum of neither readings will be correct if the instruments have inductance.

A generator runs apparently all right for 24 hours, is shut down for 24 hours, and when started up again the polarity is found to be reversed. What is the cause? J. N.

In the absence of details as to whether the generator is a series, shunt or compound machine, running alone or in parallel, and the situation with respect to other machines, no definite answer can be given. Machines are known to have changed polarity on account of mere proximity to other machines; through the inertia of the armature of a motor causing the generation of a reverse current after the main current has stopped; and through momentarily placing a shunt circuit in reverse connection with bus bars while breaking circuit.

1°. Will the static charge from a Wimshurst machine influence an electro-magnet? 2°. What is the voltage and amperage of a 12-in. Wimshurst machine? 3°. What books are there treating on such machines? J. J. S.

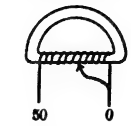
1°. An electro-magnet will deflect the discharge of a Wimshurst machine, but it is not possible to note any effect of the discharge on a magnet. 2°. Siemens found the voltage of an alternating-current spark ⅝ in. long to be 10,000 volts. De la Rue only obtained a sparking distance of .113 in. for 10,000 volts. The average current is almost infinitesimally small. A machine with twelve plates 30 ins. in diameter, driven at 5000 r. p. m., gave .000667 amperes; from this it can be seen how small is the output in amperes of a 12 in. machine. 3°. Gray's "Electrical Influence Machines," and Atkinson's "Static Electricity."

What is the process of nickel-plating on brass and iron? F. R.

The electrolyte is made by dissolving 2 lbs. of nickel-ammonium sulphate in each quart of water. The solution should be made neutral and kept so by the addition of ammonia if it be acid, or sulphuric acid if it be alkaline, though a mere trace of acidity is allowable and, some state, beneficial. It is essential that the highest polish be given the object to be plated; and that it be absolutely cleaned of grease in a potash bath, and of tarnish in the acid dip (for iron objects) or the cyanide bath (for brass, copper and zinc objects), being then washed in pure water. The former is a 5 or 10 per cent. solution of caustic potash or soda in water; the acid dip is a 25 per cent. solution of hydrochloric acid, and the cyanide bath a 10 per cent. solution of potassium cyanide. Nickel-plating is a somewhat difficult operation.

How can I make an adjustable transformer for a 50 or 100-volt alternating circuit whereby different voltages by steps of 5-volts may be obtained? N. K. L.

Bend a coil of soft iron wire in a shape similar to that of the accompanying sketch, and on the straight portion wind wire of a size fixed by the current to be drawn; if a small current, the wire may be No. 22, and the number of turns will be determined by



trial, the heating of the wire being the criterion. For this size of wire the diameter of the core need not exceed ½ in. In determining the number of turns, use a fuse in circuit. If there are, say, 200 turns, with a voltage of 50 between terminals, the voltage between turns will be approximately one-quarter volt. Owing to leakage, there will be slight differences in this figure.

How is the candle power of a search light determined? R. C.

With a photometer measure the candle power of the cylindrical beam some hundreds of feet distant from the reflector, and midway between the center and periphery; also measure the diameter of the beam at the same point. Multiply the candle power thus found by the square of the diameter of the beam, and divide by the square of the diameter of a *circle having the same area as that of the effective crater*. If, for example, the beam is 24 ins. in diameter and the effective crater .5 in., and the photometer candle power is 2000, the candle power of the search light is $2000 \times 576 \div .25 = 4{,}608{,}000$ CP. That is, an open arc light would have to be of this candle power to give an illumination at any point equal to the illumination of the beam at that point. This method of expressing the candle power of a search light is very far from being satisfactory, but is the only one in use.

Will you kindly recommend an incorporation name for an electrical society or club, to be of a purely educational nature and include in its scope lectures and exhibitions to members. C. G. S.

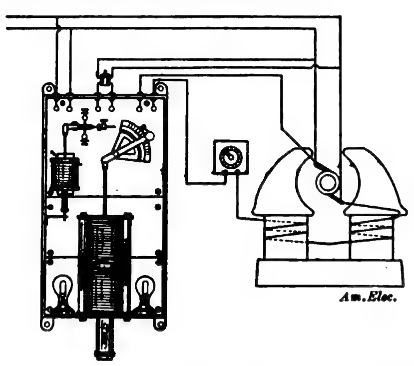
The five great classical names in the history of electrical science are Gilbert, Franklin, Volta, Faraday and Henry, to which list will in time be added the names of Maxwell, Hertz, Kelvin and Röntgen, and possibly Bell; the names of Franklin and Henry are already used in this country in the connection named, but not, so far as we know, the greatest name of all—Faraday. Should an electrical term be preferred, "Electromagnetic" would appear the most appropriate, since electromagnetism is at the base of all modern developments in the electrical field; the "Magnetic Club" is the name of a flourishing organization in New York City. "Elektron" might be suitable for the reason that for ages the word was identified with the only known manifestation of electricity, and from it was derived the present nomenclature of the science; since, however, the word merely means "amber" its use would have only a suggestive significance.

New Apparatus and Appliances.

VOLTAGE REGULATOR.

In reply to the very general demand for higher efficiency lamps whose life will compare favorably with those now in use, lamp manufacturers invariably point out that the solution of the problem lies, not with them but with the consumer. The matter of high efficiency lamps, they say, is one entirely of regulation, for a low-efficiency lamp becomes one of high efficiency if it is used at a higher voltage. Unfortunately, however, if a lamp is burned at high efficiency, unless the voltage is kept approximately constant, the life is so greatly shortened as to render such a practice out of the question. Constant voltage on distributing circuits becomes, therefore, a matter of high economic importance.

To accomplish this purpose is the object of the regulator shown in the accompanying illustrations. By its aid the voltage at a centre of distribution can be kept absolutely constant. The attachment can be used with any type of machine, either direct or alternating-current, and its range of regulation is so extended as to permit of a constant voltage being maintained on circuits supplied from generators driven by water power, or old-type alternators having no compound coils.



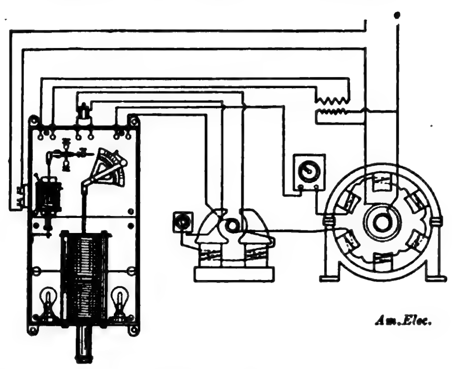


FIG. 1 AND 3.—CONNECTIONS OF VOLTAGE REGULATOR.

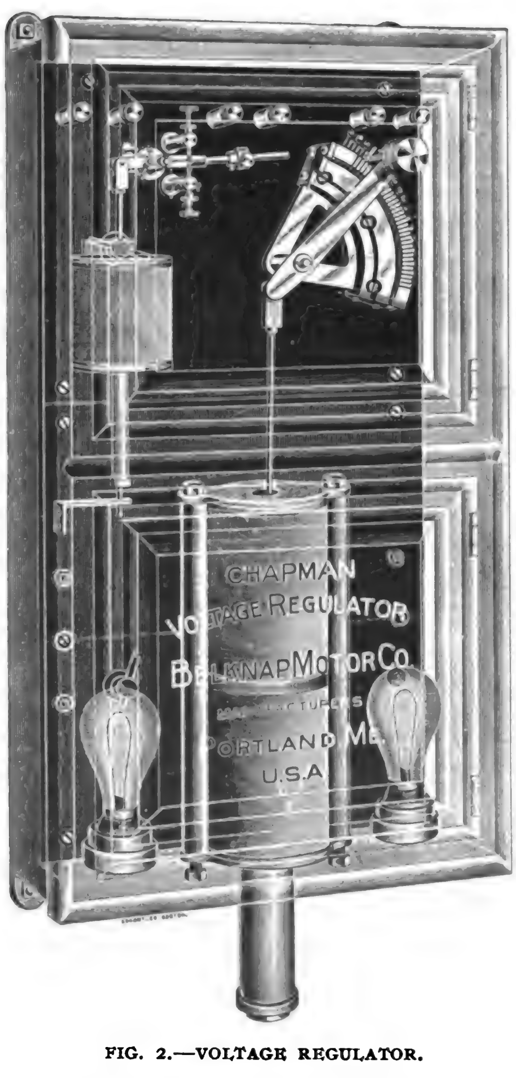


FIG. 2.—VOLTAGE REGULATOR.

Fig. 1 shows the instrument as it appears in place, and Fig. 2 is a diagrammatic representation with connections to a bipolar generator. Fig. 3 shows the connections to an alternating generator and exciter. The left hand terminals connect to the small or auxiliary solenoid, the middle ones to the large or working solenoid, and the right hand terminals to the rheostat. For connection to alternators there is an addition pair of terminals, shown on the side of the case, for compound regulation. The lamps shown at the bottom of the case are resistances for the circuit of the auxiliary solenoid.

The moving of the rheostat arm is accomplished by a working solenoid, whose action is determined by that of an auxiliary solenoid, which latter operates a set of contacts controlling the admission of current to the sections of the working solenoid. The working solenoid is differentially wound and is composed of four distinct coils, two of which have a small continuous current flowing through them, in opposite directions to each other; the contacts when operated close the circuit of one or the other of the remaining coils, and by so doing neutralize the action of one of the continuously-acting coils.

The manner of connecting secures a rise of magnetism in the iron core of the solenoid whenever a break occurs at the contacts, and so avoids the injurious sparking at the contacts that would otherwise occur through the magnetic discharge of the core; the contact points are thus enabled to be set very close, thereby securing a most sensitive adjustment of the apparatus.

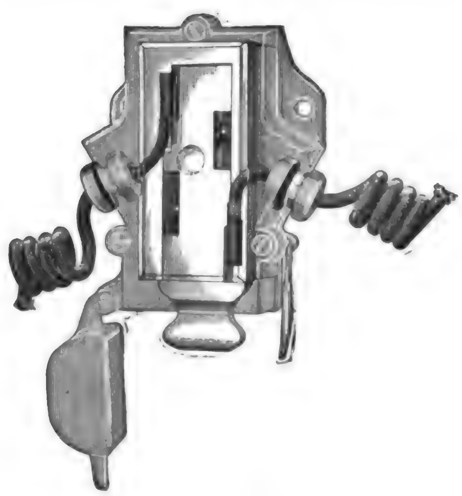
The entire work of the auxiliary solenoid is to move a lever arm with contact attached through a short space of, say, $\frac{1}{32}$ in., and a very slight change of voltage is sufficient to do this. It is often desirable to have the voltage at the generating station rise a little with the load, so that it becomes greater than the voltage at the distributing center, at the latter remaining constant with changes of load. The compounding of the auxiliary solenoid secures this result under all conditions of speed or load, and thus a plain shunt-wound generator becomes just as effective as a compound-wound generator, while the old style alternating-current generator having no compound coils, is enabled to do just as good work as the more modern apparatus.

The Chapman voltage regulator above described, is manufactured by the Belknap Motor Company, Portland, Me.

NON-ARCING FUSE BOX.

As the use of high voltages became extended, it was quickly made evident that the old form of double-pole fuse box was inapplicable to high-tension circuits and transformers on account of the possibility of short circuits.

The fuse box shown in the accompanying illustration has been designed to overcome the defects in the earlier types, the plug being so constructed as to make it impossible for an arc to form between terminals or to a transformer case when a fuse blows. As will be seen, the terminals are encased and held in position in grooves in the porcelain, thereby doing away with screws and the attendant trouble through these becoming loose and causing short circuits, loose terminals, etc. This way of holding the terminals also avoids the necessity of holes through the porcelain for the screws, which, in many cases, are the cause of short circuits and leaks through the frame of the box. The leading-in wires pass in through porcelain bushings and are soldered to the terminals, thus avoiding all trouble from loose connections. To replace a fuse it is not necessary to handle the box, but to merely push to one side the small wire or catch on the right; the lid then drops, exposing the handle of the plug which can be pulled out, the fuse renewed and plug returned to the box.



NON-ARCING FUSE BOX.

The above described fuse box is made by A. W. France, Tacony, Philadelphia.

OIL FILTER AND PURIFIER.

The filter shown in the accompanying illustration both filters and washes the dirty oil introduced into it. The lower chamber, *E*, is filled with water, which is kept heated by means of steam passed through the coil shown at the bottom; if the filter is kept in a warm place the steam connection is not necessary. The waste oil is poured through the top grating, *A*, into the chamber, *B*, whence it passes through waste into a compartment beneath, the heavier impurities being removed by the waste. From the latter it passes into the tube, *C*, which leads it under a filter plate, *D*. The greater weight of the opposing column of water tends to keep the oil in the tube, whence it slowly flows and spreads in a thin film over the lower plate, the film constantly changing surface and growing thinner as it passes from the center to the circumference. The oil then similarly flows over the surface of the two upper plates in succession, finally rising and passing through layers of waste into the chamber, *G*, whence it is drawn for use. The thin film which the oil forms on the plates subjects it to a thorough washing action by the water, while at the same time the remaining ponderable impurities are removed through the action of gravity.

FIGS 1 AND 2.—CROSS OIL FILTER.

The above apparatus, known as the Cross oil filter, is made in sizes from 3 to 120 gals. daily filtering capacity, by the Burt Manufacturing Company, Akron, O.

HIGH-FREQUENCY CURRENTS.

The accompanying illustration shows an instrument designed to serve as an X-ray generator, and also to illustrate the principle of high-frequency currents in the simplest manner possible. This instrument is arranged to be attached by an extension plug to the incandescent lighting current, either alternating or direct.

The working parts are few and simple, which fact has appealed to a great number of hospitals and physicians, who find no difficulty in manipulating the apparatus. The case shown in the cut contains the three essential features, viz., a step-up transformer, a condenser and an oscillating coil.

For insulation, all of these are immersed in a special grade of oil. The primary of the transformer is made in two sections, which are brought to binding posts on the outside, thus making it easy to adjust the instrument to different voltages by merely changing the external connections. The two poles of the current from the secondary of this transformer are connected to the two sides of the condenser. The condenser being charged, is discharged through the primary of the oscillating coil and across the spark gap in series with it. This series, of course, being in multiple with the condenser, and final current of high voltage, a great number of oscillations pass from terminal to terminal, as shown in the cut.

The new features of this instrument are many and important, among which is the combination rotary interrupter and air blast, shown attached to the motor in the cut. This latter device is a simple, convenient and reliable method of producing uniform discharge, which insures uniform fluorescence when the instrument is used for X-ray work, it being well understood that for the production of the best X-ray effects the discharge in the tube must not only be of high potential, low quantity, but must also be of sufficient rapidity and regularity to do away entirely with the flickering, which of necessity interferes with the best results.

HIGH FREQUENCY APPARATUS.

These difficulties have been so common and such a vast amount of energy has been exerted in attempts to overcome them, that the interrupter here mentioned will doubtless be of unusual interest to all experimenters with high-frequency apparatus. This device, which seems so simple in construction, is what has made the high-frequency coil so pronounced a success for X-ray work. The manufacturer is the L. E. Knott Apparatus Company, Boston, Mass.

TELEPHONES FOR SPECIAL SERVICE.

The accompanying illustrations show some late types of telephones designed to meet the demands of special service. The instrument shown in Fig. 1 is used principally on country exchanges and farmers' lines, the large demand for this class of work in the recent past having necessitated a special instrument for this purpose. This instrument is equipped with a 10,000-ohm magneto with all the latest improve-

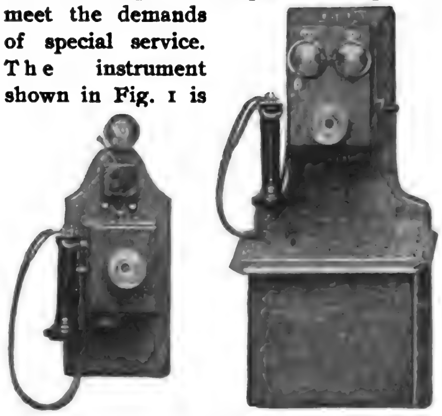


FIG. 1 AND 2.—TELEPHONES FOR SPECIAL SERVICE.

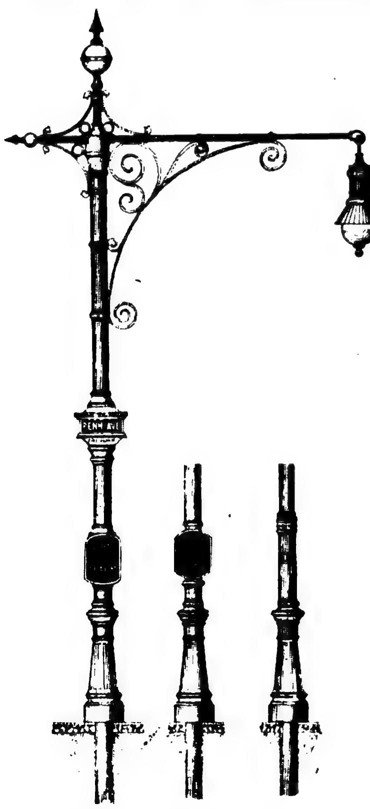
ments, and is on a highly finished back-board and battery box, the arrangement being very compact. A transmitter and induction coil are fitted in the magneto case. Fig. 2 represents a new design of telephone for interior communication on short lines. This, it will be seen, is a handsome instrument. The bell, transmitter and complete telephone working parts are fitted on a 14-in. backboard, leaving a space below for switches.

Both the above telephone sets are manufactured by the Chicago Telephone Supply Company, 120 Quincy Street, Chicago.

ORNAMENTAL ELECTRIC-LIGHT POLES.

Comparisons unfavorable to American street pole line construction have been frequent in the past, particularly by those who have observed the attention from the æsthetic standpoint which this matter has received in Europe. An arc pole line recently constructed by the Potomac Electric Power Company, at Washington, D. C., is free from reproach of unsightliness, and the poles in addition possess other features highly commendable.

As will be seen from the accompanying illustration, the poles are not only handsome in appearance, but serve to perform some useful offices not usually associated with an electric-light pole. They are so designed that an illuminated street sign and a fire or police alarm or letter box may be built in the pole—not merely strapped on in the usual unsightly manner, but made to form part of a harmonious whole. The street sign is



ORNAMENTAL ELECTRIC-LIGHT POLE.

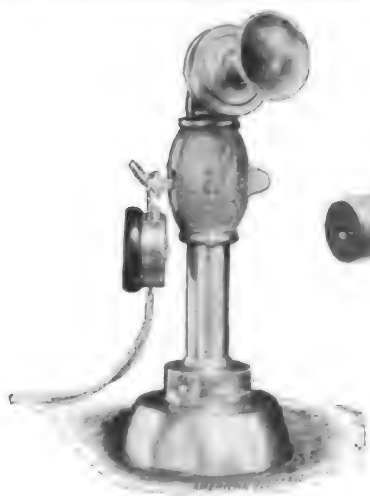
illuminated by an incandescent lamp. Still another style has a base fitted with fire-hose water connections.

Another feature is that no provision has been made for lowering the lamps for trimming, which, from an æsthetic point of view, is very gratifying since there are no ropes, windlasses, loose wires, insulators, etc., in fact no wire, rope or rigging of any kind to be seen, and the danger from moving wires and lamps falling in the street is thus avoided. The lamps are trimmed with a special light tower wagon which is found on the whole as cheap and more desirable than the old method, since a man can trim many more lamps and much more satisfactorily in this way.

The poles were designed by Mr. C. A. Lieb, and are made by Morris, Tasker & Company, Philadelphia.

PORTABLE DESK TELEPHONE.

The accompanying illustration shows a new type of portable desk telephone, the instrument being entirely self-contained, with the switch contacts protected from dust or

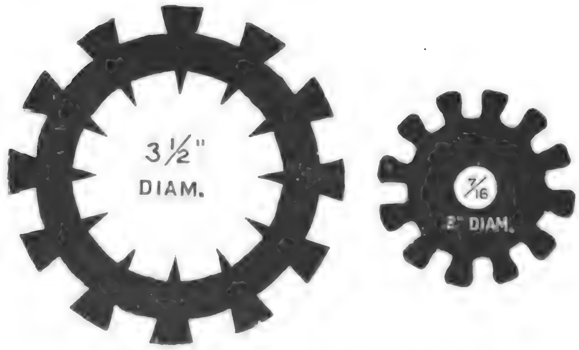


PORTABLE DESK TELEPHONE.

mechanical injury. The set is fitted with an Erickson transmitter and watch case receiver, and as all parts are entirely nickel-plated, the combination is altogether a handsome instrument and may even be considered an ornament to any desk. This portable desk telephone set is manufactured by the Electrical Engineering Company, of Minneapolis, Minn.

ARMATURE PUNCHINGS AND CASTINGS.

For the information of such of our readers who take pleasure in building small electrical machines, we print herewith illustrations, with dimensions, of an armature disk and casting, the latter being made of a grade of cast iron whose magnetic qualities



ARMATURE PUNCHINGS AND CASTINGS.

almost equal those of wrought iron. These and other parts of the small motors whose construction is described in our columns, are made by the Cherry Electric Works, 25 Third Avenue, New York.

NEW WALKER RAILWAY MOTOR.

The new type of Walker motor shown in Fig. 1 has a capacity of 30 HP, and contains several specific improvements entirely new in electric railway motor construction. In this type the side arm suspensions have been made much more massive, but as they are cored out hollow, lightness is combined with rigidity. The suspension device has but four parts. The bearing on the car axle is of babbit and is carefully scraped. This suspension frame carries all the grease cups, which have been made larger, and grease and oil are not allowed on any part of the motor itself. The motor bearings are entirely outside the case and all refuse lubricant falls on the ground and cannot enter the motor. The pinion bearing is 8 ins. in length instead of 6 ins. as is ordinarily the

FIG. 1.—END VIEW OF ARMATURE.

case, and this additional bearing surface notably increases the life of the bearing. The stresses on the pinion bearing are much more severe than those on its mate, and the Walker Company has been the first to thus provide for this.

Of the principle of the suspension, it is sufficient to call attention to the fact that the rigid connection which keeps the gears in mesh does not in any way interfere with the motion of the motor as it moves under the vibrating influence of the car. To obviate pounding, this motion is limited and absorbed by springs, which also take the strain off the gears when the armature is momentarily blocked by inertia or severe torque.

The field of the motor is wound of a size larger wire than any other makes of equal capacity. The field coils are rectangular both in shape and in section, and thus no special tools are necessary in making repairs on them. There are four field coils in all, each pole being salient, and thus the field is perfectly symmetrical. The effect of this is to minimize sparking and avoid uneqnal distribution of work in the armature winding. The advantages of a four-field winding are beginning to be appreciated and used more generally. The field coils are thoroughly soaked in a fire and water-proof compound, and thus rendered impervious to heat or moisture. The motor casing has apertures at both ends of the armature in its upper half. Thus, either end of the armature can be inspected without opening the motor. This is an exclusive advantage of this type of motor, and quite an important one. These lids are provided with ventilating holes that keep the armature materially cooler in seasons of overload. The holes are so designed as to render it impossible for dust or moist-

ure to enter. The familiar eye-bolt hinge which permits the tightening of the magnetic joint between the case halves is retained. The new case is octagonal in shape whereas the old one was cylindrical.

The armature has also been materially improved. The barrel system of winding is used, but the coil has been improved so that it is now so short that the completed armature is fully as short as the armature using connectors passing over the ends. In fact, one of the new armatures can operate in the old field, thus conclusively proving that its length has not been increased. The great advantage of the barrel winding is the ease with which its coils may be slipped on, the small proportion of dead wire, and the fact that the principal band wires can be placed outside the clearance where they are neither limited as to size nor so heated by eddy currents as to melt the soldered joints. Further than that, they cannot in this secure position be cut by the rubbing of the armature against the pole-pieces, which would perhaps happen if the bearings were neglected. This is quite a common accident on other motors.

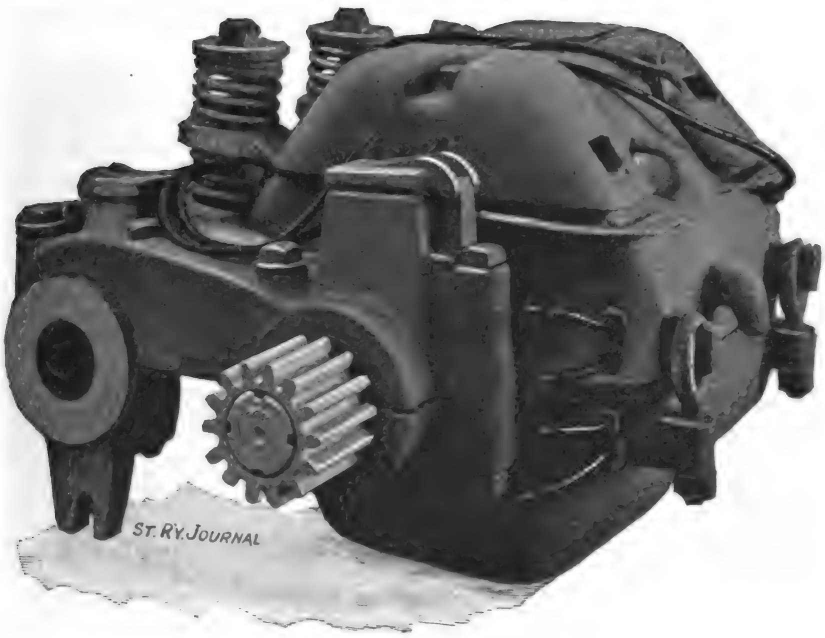


FIG. 1.—NEW WALKER MOTOR.

A serious objection to the ordinary barrel winding which renders it worthless for a railway motor, has been successfully overcome in the Walker winding. The cylindrical extension formed by the end connectors is very susceptible to damage and is a great harborer of dirt and moisture on its interior. The Walker coils are protected by an oil, dirt and damage-proof iron armor formed by extending the end casting so as to support and contain the ends of the coils.

The slots in this armature are quite wide as they contain two coils side by side. The teeth are long enough to admit of a strip of wood being wedged in above the coils, which effectually protects them when the armature is rolled over the floor. Fig. 1 gives a good idea of the commutator and of the armature.

The commutator is very large and has 108 bars, thus making the voltage per bar very low. The lugs are brought out equal to the armature diameter. The mica collar, preventing flashing on to the shaft, has been enlarged and improved. The regular process of forming the commutator under enormous pressure is used, and all the squeeze and give is taken out of the commutator insulation so that sufisequent sinking of the bars is an impossibiiity. The armature coils are of stranded wire and it is practically impossible to break them by repeated bending. There are no joints in the winding except at the commutator lugs. The maximum efficiency of the motor is 89 per cent—an extremely high figure for such a motor—and the efficiency curve is remarkably flat.

A NEW PRIME MOVER.

A new and interesting type of the free jet or percussion wheel (which may be operated by either steam or water) is shown in principle in the accompanying illustrations. This wheel is claimed by the inventor to go beyond anything of the sort hitherto known in developing maximum efficiency from the motive power.

It is an established fact in hydraulics that

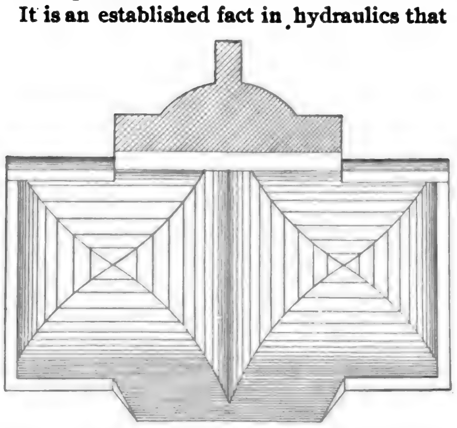


FIG. 1.—FRONT VIEW OF PAIR OF BUCKETS.

the jet of water must be completely inverted by the vane or bucket of a wheel, traveling at half the velocity of the jet, in order to obtain the best results in transmitting the inherent power of the jet. In a pamphlet which may be obtained upon application to the manufacturers, it is shown in detail how this theoretical requirement for maximum efficiency is fulfilled in practice, and the accompanying cuts illustrate some of the peculiar features of the new wheel, particularly the shape and arrangement of the impact vanes.

Fig. 1 is a front view of a pair of buckets, in which the curves of the receiving lip and vanes are indicated by the shaded lines. Fig. 2 is a section through ane of the vanes showing not only the true curves, but also the course of the jet in contact therewith. Fig. 3 shows the positions of the vanes on the wheel crown, and also the diagonal-nozzle type intended to provide against loss of power between the time that the jet

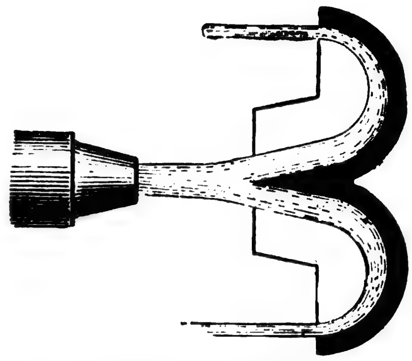


FIG. 2.—SECTION OF VANES, SHOWING IMPACT OF WATER.

leaves the nozzle and contact occurs with the buckets.

These cuts indicate the main features of the device, and in the pamphlet referred to, it is shown that the construction employed causes the jet to be not only inverted while the bucket is in its best position relative to the jet, but also completely and permanently in all positions taken by the bucket while receiving the jet impact—a necessary condition to highest efficiency which is claimed to have been hitherto overlooked by wheel manufacturers. The inventor is Mr. F. M. F. Cazin, and the wheel is offered for sale by the American Impulse Wheel Company, 120 Liberty Street, New York, who will furnish copies of the book above referred to upon application.

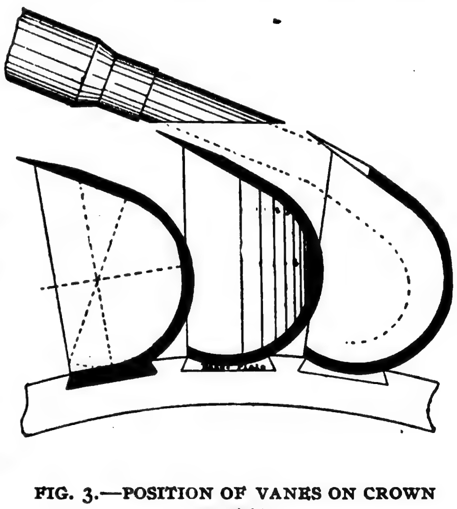


FIG. 3.—POSITION OF VANES ON CROWN WHEEL.

ELECTRIC HOISTS.

The application of the electric motor to hoisting work and the appreciation of the combination by mine operators, is shown by the numerous installations of electrical hoists which have been made in mines during the past few years. We illustrate herewith sev-

eral types of such hoists made by the General Electric Company, that in Fig. 1 being installed at the Free Silver mine at Aspen, Col. This is the largest electrical hoist in world, being rated at 125 HP, but capable of applying to the hoisting machinery power to the extent of 200 HP. In design it is a double reel, flat rope, over-balanced hoist.

The electrical equipment consists of one General Electric Company's 100-KW multipolar motor, with a speed of 550 r. p. m., and a smaller motor of similar type of 60 KW capacity and a speed of 475 revolutions.

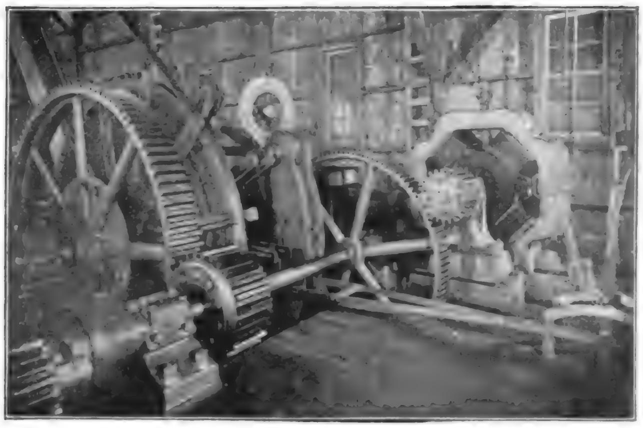


FIG. 1.—OVER-BALANCED ELECTRIC HOIST—FREE SILVER MINE, ASPEN, COL.

This smaller motor is ordinarily used to run an air compressor and winch for pulling pumps, but in case the main hoist motor is called upon for heavier work than usual, the smaller one can be thrown in gear with it.

The maximum hoisting speed with the cage and ore, and using the small pinion on the motor, is about 600 ft. per minute; with a bailer attached and filled with water, using the larger pinion, about 1000 ft. per minute.

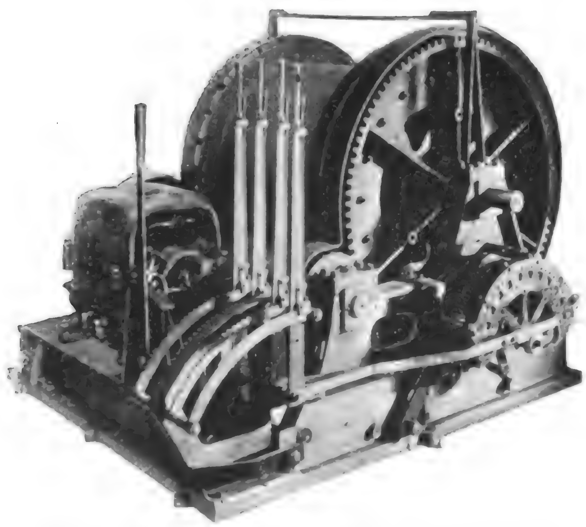


FIG. 3.—ELECTRIC HOIST—PLEASANT VALLEY COAL COMPANY, CASTLE GATE, UTAH.

The voltage used is 525 volts, and the current is taken from the central station at Aspen.

Fig. 2 shows a hoist at the Alta Argent mine, also at Aspen, which is placed at the head of the incline. The current is taken from the power plant of the Roaring Fork Electric Light & Power Company, 3½ miles distant, 2 miles being above the ground and 1½ miles through the Cowenhoven tunnel and mine workings. This hoist is also over-balanced and is equipped with a General Electric Company's multipolar, slow speed, 500-volt motor, having a capacity of 20 HP.

In the mines of the Pleasant Valley Coal Company, at Castle Gate, Utah, is another direct-current mine hoist used for hauling the coal cars up the incline, and shown in Fig. 3. This hoist is a Lidgerwood double-reduction, single-drum hoist, equipped with a standard L. W. P. 20-HP railway motor and double "51" rheostat. It is designed to lift 4000 lbs. 500 ft. per minute. The drum is 47 ins. in diameter and 36 ins. face, with two brake hands in V-shaped grooves on the drums. It is provided with both friction and positive clutches, and is operated by five levers—one for the rheostat, one for the friction clutches, one for the positive clutch and two for the brake. Another hoist of similar pattern (Fig. 4) but using a friction clutch only and a G. E. 2000 motor with a double 83 rheostat, has recently been added to the very complete mining equipment of the Pleasant Valley Coal Company. The motor in this case is fully enclosed.

All the above hoists, as well as many more of the same manufacture, have been in constant service for months without serious hitch or stoppage beyond those necessitated in ordinary mine service. They have been found superior to steam hoisting engines, both in efficiency, in simplicity, in convenience, and in speed of operation.

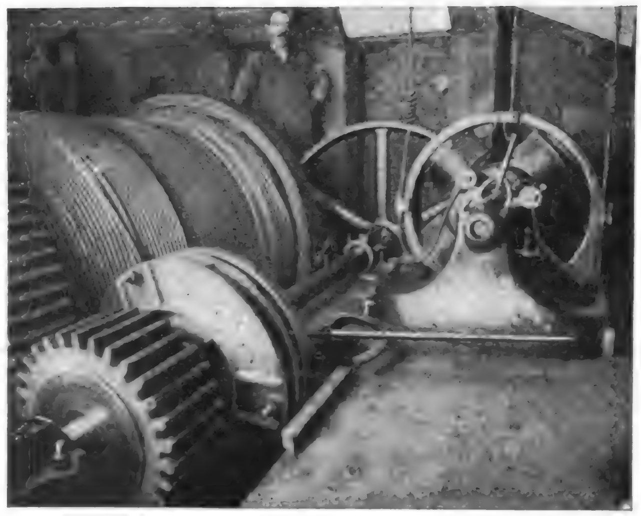


FIG. 2.—ELECTRIC HOIST—ALTA ARGENT MINE, ASPEN, COL.

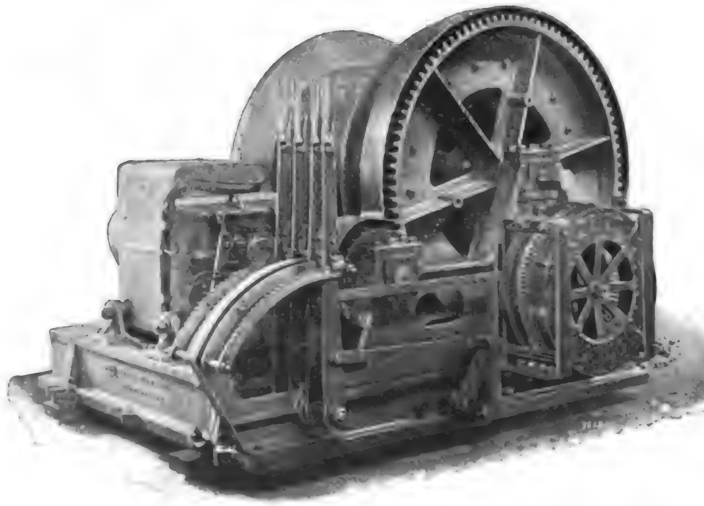


FIG. 4.—ELECTRIC HOIST—PLEASANT VALLEY COAL COMPANY, CASTLE GATE, UTAH.

STORAGE BATTERY.

That the Planté type of storage battery has many excellent points peculiarly its own, has long been recognized by those conversant with the subject, and in the past few years this type has begun to resume its former popularity. Among recent forms of this type is one illustrated herewith, the plate of which, as will be seen from the cut, consists of a single integral piece of pure lead in the form of an open-worked, ribbed and grooved plate, without any border.

The ribs of one side of the plate cross those of the other side, and are bodily, and consequently, electrically, joined to them. Where strength and durability are first considerations, the plates are made heavier, every tenth rib being made thicker, and the adjoining grooves wider. The plate is made either by casting in a mould or by pressing, rolling or sawing it out of a piece of pure sheet lead. A plate so constructed has necessarily greater strength and a larger exposed surface, for a given weight, than other forms of ribbed plate. The central web or sheet of lead used with horizontally parallel ribbed, borderless plates, is here absent, thus diminishing the weight and increasing the surface without impairing the value of the plate. The active material, as in all batteries of the Planté type, is formed directly

from the plate itself, during the forming charge.

The time required for forming the plates varies from about thirty to fifty hours, though this may be shortened by varying the forming solution, and the strength of the current. The "formed" active material is very fine grained in texture, and compact and adherent. The average capacity ranges from three to five ampere hours per pound of element, though a much higher

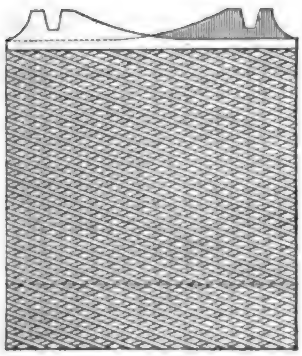


FIG. 1.—BATTERY PLATE.

capacity can be obtained where excessive lightness of plate is desired. The internal resistance of the cell is very low and the insulation of the plates is such as to entirely prevent any internal local discharge. The battery will stand an excessive charge and discharge rate, without sustaining injury. For some uses, the positive plates are specially protected by perforated sheets of insulating material secured to the plates by means of soft rubber bands, or otherwise.

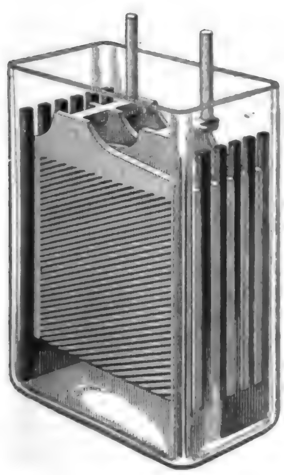


FIG. 2.—PLANTÉ BATTERY.

This prevents scaling or bridging. The manufacturers state that the battery has been subjected to severe, repeated and continued tests for a period of eighteen months, without showing signs of disintegration or decreased capacity, and that it is manufactured under non-infringing patents, lately issued, which guarantee protection against litigation.

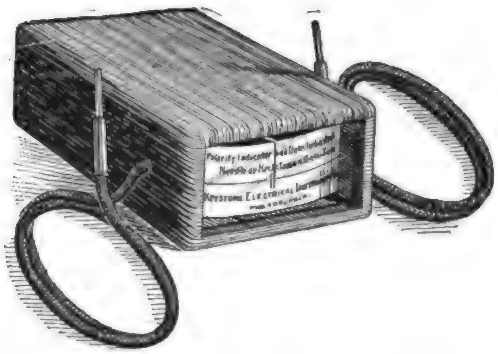
The above described battery is made by the New York Accumulator & Electric Company, 150 Nassau Street, New York.

POLARITY INDICATOR AND DETECTOR GALVONOMETER.

The instrument illustrated is designed to indicate polarity of light and power mains on two and three circuits as well as the polarity of dynamos and batteries.

It will indicate on circuits from 1 volt to 700 volts, and a short circuit cannot be made through it. Among its uses are for setting arc lamps and motors and as a general pocket detector galvanometer.

The instrument is mounted in a neat, polished walnut case small enough to be carried in the pocket; it weighs but 4½ oz. and is fitted with terminal leads. The pointer always deflects toward positive terminal.



POLARITY INDICATOR AND DETECTOR GALVONOMETER.

The manufacturers are the Keystone Electrical Instrument Company, Ninth Street and Montgomery Avenue, Philadelphia.

GRANULAR CARBON TELEPHONE.

The granular carbon transmitter illustrated herewith is a distinct departure from

GRANULAR CARBON TELEPHONE.

other types of microphones. Its particular features are a parchment diaphragm, and the containing cap over the rear electrode of the same material, thus doing away entirely with metallic parts. Another feature of this transmitter, and one that will be appreciated by those familiar with microphones, is the method of connecting the electrodes to the lead wires. Many forms of other transmitters using carbon diaphragms depend upon some metallic shoulder as a seat and lead for the diaphragm. This shoulder in a very short time, even in the most efficient types, becomes corroded from various causes, thereby failing to take up the minute variations, which tends to lessen efficiency. In this instrument the leads from the front and back are soldered directly to the diaphragms, which makes a positive connection, and obviating corrosion from moisture or any other cause.

A peculiarly sensitive carbon is used in the construction of these transmitters, of which only a very small portion is required (about .25 gramme) to obtain the highest and lowest points of resistance. The extreme lightness of the diaphragm, the small amount of carbon required, and freedom from loose connections, are claimed to constitute this a most efficient type of transmitter for long and short distances. The Clark transmitter is manufactured by the Clark Telephone & Construction Company, Minneapolis.

TANDEM COMPOUND CORLISS ENGINE.

The tandem compound engine shown in the accompanying cut is of the Corliss type, but with some radical improvements introduced. The valve gear has been so designed that all strains are brought as nearly as possible in the same plane, and the wearing surfaces are made larger than in other engines of this type.

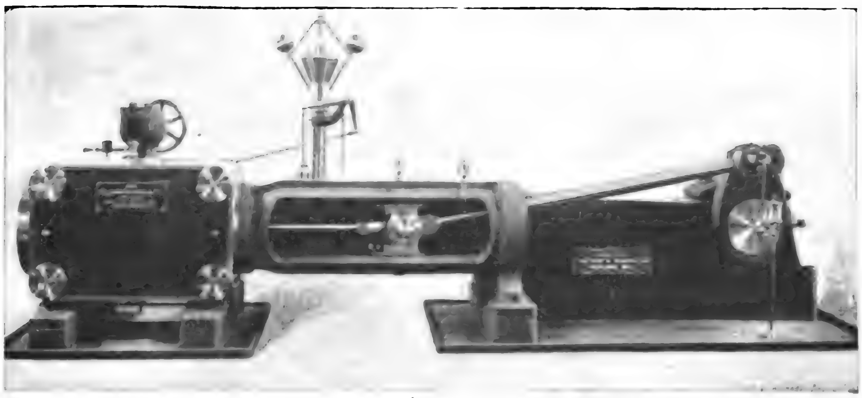
The standing parts of the engine are proportioned so as to preserve the alignment, thereby insuring freedom of motion to the working parts and preventing shocks and jars caused by the momentum of these working parts. The cylinder clearance spaces have been reduced to a minimum, and the steam ways so arranged as to obviate all preventable losses in the passage of the steam.

The drop lever keyed to the steam valve stem is supported in the bonnet, thus relieving the stem from transverse pressure. The hardened steel latch dies have eight wearing surfaces, and are provided with an adjustment whereby the amount of lap of the dies may be reduced or increased while the engine is running. This arrangement obviates any possibility of the valve gear not "hooking in," which defect is often found in Corliss engines after the dies are somewhat worn. The hook rod is provided with a special device for disconnecting the valve gear from the eccentric motion, thus not rendering it necessary to hold up the rod during the time the engineer is starting or stopping the engine.

The construction of the steam and exhaust valves and the design of the valve motion are such that the angular advance is small, which means a greater range of cut-off under control of the governor. The angles of travel are also reduced with a corresponding reduction of wear and tear. The governor is designed for a limiting variation of two per

cent. in speed, and can be made to govern even closer for electric lighting purposes by the addition of a special attachment.

The engine described, which is of the

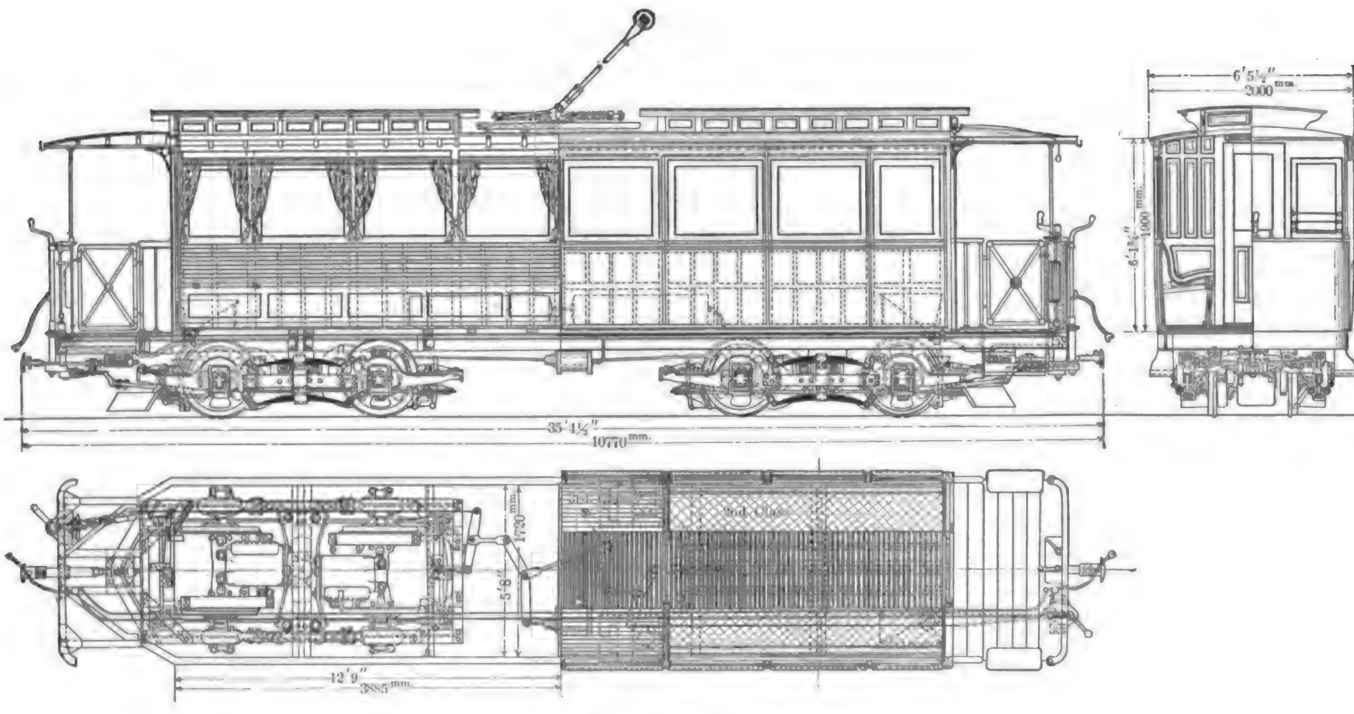


TANDEM COMPOUND CORLISS ENGINE.

design of Mr. J. H. Horstman, is made by the Filer & Stowell Company, Milwaukee, Wis.

A GERMAN MOTOR CAR.

While electric traction on steam roads has scarcely yet passed beyond the stage of discussion in this country, at least one European steam line has taken advantage of the superior economy offered by electricity and is rapidly passing from steam to electric power. The road referred to is one passing through



GERMAN MOTOR CAR.

an industrial region in upper Silesia, Prussia, and is known as the Oberschlesische Dampfstrassenbahn system.

Thirty motor cars and fifty trailers will be put into immediate service. The motors with which these cars will be equipped are of the Walker make and the brakes will be of the Standard Air-Brake type. The accompanying engravings give side and end elevations of one of the motor cars. As will be noticed, there are compartments for both second and third-class passengers. The "Standard" air-brake was specified for the entire installation in view of the satisfactory results which had attended the use of this brake on the Grosse Leipziger Strassenbahn in Leipzig, Germany. On the latter road over 300 Standard brake equipments are in use.

The Oberschlesische is a road of extremely narrow gauge, the track having a width of but 30 ins. In order to furnish adequate power, motors will be placed on each axle, that is, four to a car, these motors being of a specially narrow type. There was no room therefore on the axles of the car for axle-type compressor. On this account the gearless motor-driven compressor will be used.

The hand brake staff is retained in addition to the air-brake, and will operate in conjunction therewith if required. The brake rigging, however, is arranged to secure uniform pressure alike on all the wheels, and the train, when filled, will weigh over 50 tons. The steepest grade along the road is 5 per cent. and cars will maintain an average speed of 16 miles per hour. The motor compressor furnished in this installation occupies a space of 16 ins. × 24 ins. × 18 ins.

NEW BOOKS.

LES TRAMWAYS ÉLECTRIQUES. Par Henri Maréchal. Paris: Boudry et Cie. 203 pages, 115 illustrations. 7 fr. 50.

The greater part of the matter in this volume, which in its scope is mainly descriptive, was gathered by the writer on a recent visit to the United States, and, therefore, presents little that is new to the American reader. The chapter on storage battery railways gives much information relating to the Paris storage battery lines, and underground trolley systems are quite fully treated.

POWER DISTRIBUTION FOR ELECTRIC RAILWAYS. By Dr. Louis Bell, Ph. D. New York: Street Railway Publishing Company. 268 pages, 139 illustrations. Price, $2.50.

The co-author of the first important book on the electric railway—Crosby & Bell's "Electric Railway"—Dr. Bell, needs no introduction to the electrical reading public. With his thorough acquaintance with everything pertaining to the electric railway, and his high abilities as an engineer and writer, it is particularly fortunate that this much-needed work comes from his pen. The volume is one of the rare books that may be called indispensable to those interested in the subject it treats, for it is not only the pioneer in the branch of electric railway construction, but an engineering treatise exhaustive in its extent. Fundamental principles form the subject of the first chapter, after which the return circuit, and direct and special methods of distribution are considered. Chapters on substations and transmission of power for sub-stations follow, and a most interesting chapter is devoted to alternating motors for railway work. The final chapters are on interurban and cross-country work, and fast and heavy railway service.

TRADE PUBLICATIONS.

Electric Safe Protection. The Bankers' Electric Protective Company, Chicago, Ill., describes in a large page pamphlet its electrical method of safe protection, the details of which will be found of interest by electricians.

Water Tube Boilers.—The Standard Boiler Company, Marquette Building, Chicago, has issued a handsomely printed circular describing and illustrating the "Standard" water tube safety boiler. A list of users shows that this boiler is installed in some of the most important establishments in the country.

Telephones. The St. Louis Electrical Supply Company, 911 Market Street, St. Louis, has issued a

compact 48-page catalogue, dealing entirely with telephones and telephone supplies. Everything imaginable in that line will be here found and described, thus making the pamphlet a useful one for reference to those engaged in this line of work.

Walker Monographs.—The two latest Walker circulars are devoted respectively to a description of the electrical power generating plant of the Brooklyn Bridge, and to the Walker street car motor. A complete technical description is given of the Brooklyn plant, and in the motor circular the destinctive features of the Walker street railway motor are illustrated in detail engravings.

Rail Bonding. The Forest City Electric Company, Cleveland, O., has issued a 40-page handsomely illustrated book entitled "Rail Bonding and the Protected Rail Bond," in which the subject of rail bonds is given a more thorough treatment than it has yet received elsewhere. The book is bound in leather and of pocket size, and is sent free upon receipt of 10 cents to cover cost of mailing.

The Warren Alternator. The Warren Electric Manufacturing Company, Sandusky, O., has issued a handsomely printed and covered pamphlet describing and illustrating the Warren alternate-current generator. The various details of the machine are clearly set forth, and a number of fac-simile letters printed from users of the Warren alternator, in which its excellent properties are extolled. The technical matter in the above publication is also embodied in a smaller pamphlet, with an additional illustration showing the coils in detail.

Steam Indicators and Appliances. James L. Robertson & Sons, 58 Cortlandt Street, New York, in a 32-page octavo catalogue describe and illustrate their various steam specialties, most of which are known as standard articles throughout the United States. The first half of the pamphlet is devoted to the Robertson-Thompson indicator, indicator card planimeters, reducing wheels and other indicator fittings. The pages on the indicator furnish one of the clearest, common sense expositions of the technical features of that instrument that has yet been published.

Alternating-Current Motors. The Wagner Manufacturing Electric Company, St. Louis, Mo., in its Bulletin No. 2. gives a detailed and technical description of the Wagner self-starting, single-phased, alternating-current power motor. The writer of the bulletin furnishes a strong argument against the frequent assertion by partizans of the polyphased system, that their system is alone sufficiently flexible for both motor and power service. It is stated, on the contrary, that the Wagner motor, will exceed in efficiency and all-round successful operation, any type of polyphased motor.

The Electrotherm. A recent circular of the H. W. Johns Manufacturing Company is devoted to the electrotherm, or electric heating pad. This useful appliance is now firmly established in the favor of the medical profession, who quickly recognized its excellent qualities for the local application of heat. It is regularly made in several different forms—for ordinary domestic use, to replace hot water bottles, etc.; specially for moist heat; and as a foot warmer. Special forms, such as special collar, chest and back pad combined, mats for operating tables, sweating jackets, etc., are made to order.

Voltage Regulation. In a circular the Belknap Motor Company, Portland, Me., gives detailed information concerning the Chapman voltage regulator. This regulator, which has met with much success, has been designed to meet the undoubted need for a practical voltage regulator for water-power and other badly regulating plants. One of its most important applications is to systems supplying both light and power where otherwise the motor load is apt to render the lighting unsatisfactory, and to unfavorably affect the life of lamps, if it is attempted to use a high-efficiency type.

Enclosed Arc Lamps. Catalogue No. 9 of the General Incandescent Arc Light Company, 572 First Avenue, New York, is devoted to the Bergmann Bijou long-life enclosed arc lamp. This lamp is of a miniature size, and is especially suitable for small interiors and rooms with low ceilings. It is made in sizes from 2½ to 5 amperes of current capacity, and varies in length from 23 to 31 ins. The life of the carbons is either 50 or 100 hours, depending upon the size of the lamp. As a peculiarity of the enclosed arc lamp, it may be noted that for the Bijou lamp the length of the upper carbon is 10 ins. for 100 hours and 8 ins. for 50 hours, and the lengths of the lower carbons 4½ ins. and 4 ins. respectively—the ratios of lengths to life thus departing widely from those which obtain with open arcs.

Electrician's Pocket Handbook. The Standard Underground Cable Company, Pittsburgh, Pa., has just issued a fifteenth edition of its very useful pocket handbook of information relating to cables and cable fittings and electrical information in general. On cable work it forms undoubtedly the best technical manual in print, every detail being thoroughly treated. Complete instructions are contained for installing all classes of cables and accessories including conduit laying, cable laying and jointing, application of protective devices, etc. Methods of testing cables, locating faults, etc., are discussed and explained with diagrammatic figures. Another portion of the book contains many tables of general and electrical information, including tables containing complete data as to the diameter, weight and resistance of solid and stranded copper wire, some of which are more comprehensive than any heretofore published. Several pages treat of the effects of alternating currents, and changes of electrical properties with change of temperature. The question of electrolysis is thoroughly discussed in a chapter by the company's electrician. The book, which contains 182 pages, is substantially bound for the pocket.

BUSINESS NEWS.

The Standard-Air Brake Compony, New York, reports good business for March, and in addition to deliveries at home, secured several good orders from abroad, including one by cable for air brakes for the colonies.

The Puritan Electric Company has moved its offices to 732 American Tract Society Building.

J. L. Robertson & Sons will remove their offices to 204 Fulton Street, on or about May 1. An office and salesroom have been opened at 12 Pearl Street, Boston, with Frank Robertson in charge.

E. P. Roberts & Company, of Cleveland, O., consulting electrical and mechanical engineers, have just removed their offices to the Osburn Block. The new location is in every way more desirable than the old, as the firm has more room and the offices are more conveniently arranged.

The Ball Engine Company, Erie, Pa., has furnished to the Paul O. Stensland building of Chicago, an engine for a direct-connected generating unit, the dynamo, being furnished by the Jenny Electric Company, Indianapolis. This is the third direct-connected outfit furnished by the same companies in this building.

The Harrison International Telephone Construction Company, 196-200 S. Clinton Street, Chicago, states that it is running its factory on full time and is about to largely increase the working force. This company manufactures one of the latest improved telephones and is receiving many large and substantial orders for exchanges.

The Electric Appliance Company reports that it is rapidly closing agency arrangements in different parts of the country for its 1897 line of fan motors and ceiling fans. It is offering a full line of direct and alternating fan motors, and also a full line of direct and alternating-current ceiling fans, and is prepared to offer attractive arrangements to good live agents.

The Commercial Telephone Equipment Company was recently organized with temporary offices at Rensselaer, Ind., for the purpose of controlling the Stromberg-Carlson telephone apparatus in Kentucky, Indiana and Michigan. The company will shortly remove to Indianapolis. The organization of the company is made up of Indiana capitalists, the capital stock being $25,000.

Schiff-Jordan & Company, the well known carbon manufacturers, have moved their office to 232 Greenwich Street, where they have engaged two floors for storage purposes. This change was occasioned by the steadily increasing demand for the Schiff-Jordan carbons, especially since Jan. 1. All communications to the firm should be addressed to Post Office Box 1726.

The Clark Telephone & Construction Company, of Minneapolis, reports a big run on its new transmitter throughout the Northwest, and also the receipt of some very substantial orders from Canada and South America. Even better than this, as illustrating the extent of American manufacturers' sales, it shows a very substantial order from Johannesburg, South Africa.

The Metropolitan Electric Company, of Chicago, has been given the agency for the Thompson-Brown arc-light hanger board. This, which is claimed to be one of the best hanger boards on the market, is neat, of good mechanical construction and a good seller. It fills all the requirements of the underwriters, and has met with the approval of the best electricians.

The Varley Duplex Magnet Company has removed its offices to 138 Seventh Street, Jersey City. About half of the plant had been moved to the above place, owing to lack of room at the New York works, and the latter again having become crowded, this final change was made, thus obviating the great inconvenience that had been felt by the division of the plant in two parts located in different cities.

Mr. Geo. C. Bailliard, an active salesman with the General Electric Company in the lamp department, has decided to sever his connection with that company. He has not decided as yet what company he will unite himself with, if any, but it is not probable that he will want for opportunity, as he is a man of large business acquaintance, great tact and ability. He is the kind of salesman that carries his customers with him.

The Bossert Electric Company, Utica, N. Y., has arranged for the construction of new and extensive quarters for its manufacturing departments. Four buildings will be erected, the main one to be 44 ft. × 88 ft. and designed for three stories, of which two will be built at once. Three smaller brick buildings will adjoin the main structure, of which one will be used for enameling, a second as a power house and the third as a boiler house.

The Stromberg-Carlson Telephone Manufacturing Company, Chicago, Ill., recently made some changes in its organization, the officers of the company now being as follows: A. Stromberg, president; A Carlson, vice-president; A. B. Cotton, secretary, and F. A. Ross, general manager. Mr. Ross, who has just become connected with the company as its manager, reports that the prospects for business are unusually bright.

The Detroit Insulating & Manufacturing Company, Detroit, Mich., was recently organized for the purpose of furnishing cut and stamped mica for electrical purposes. A specialty is made of commutator segments gauged ready for use. August Tinnerholm, the manager of the company, has had ten years' practical experience with the General Electric Company and the Westinghouse Electric & Manufacturing Company.

Commutator Compound. Jas. McLaughlin, 586 Fulton Street, Chicago, is in constant receipt of letters commending the merits of his commutator compound, of which the following from the treasurer of the Cambridge (Mass.) Electric Light Company, is an example: "We enclose check for bill of compound for commutators and $5 additional, for which please send the amount in compound. We consider it invaluable and shall use it continually."

Wm. Baragwanath & Son, 48 Division Street, Chicago, Ill., report that business during the past month has been quite brisk and the outlook for the future is favorable, as inquiries concerning their feedwater heaters, purifiers, condensers, pumps, etc., are numerous. Among the sales during the past month were three heaters of 75 HP, one of 100, two of 150, and one each of 200, 300, 400, 600, 800 and 2000 HP; two open heaters of 300 HP; a condenser of 500 HP and a purifier of 600 HP.

Fred. M. Locke, Victor, N. Y., reports a very good demand for his well-known insulators. Among the shipments just made is one of 5000 china insulators and 5000 steel pins to a point in South America; also one of 2000 china insulators and 2000 steel pins to Japan, and still another of 2000 steel pins and 2000 insulators to a point in Mexico. In addition to these, he has also recently made ten other shipments to foreign countries besides numerous shipments to points in this country.

The Chicago Telephone Supply Company, 120 Quincy Street, Chicago, reports a very marked increase in its trade for the past month. Its three years' experience in the telephone trade has witnessed an extension of business throughout every section of the United States and Canada, and the growth of an enviable reputation in the telephone

field for first-class work. A new catalogue has just been issued, illustrating and describing the various lines of telephones handled.

The Northern Electrical Manufacturing Company, at Madison, Wis., is doing a brisk business notwithstanding these slow times. The shops are full of busy men, and its manager reports a brisk demand for steel-clad invertible motors for shop use. The Northern Company is making a specialty of direct connection of its motors to printing presses and all kinds of machinery. Its motor is very compact, is strictly up to date in all particulars, and is bound to be popular in the machine trade.

The American Rheostat Company, Milwaukee, Wis., at its recent annual meeting accepted the resignation of L. T. Gibbs; F. R. Bacon, the former vice-president, succeeding him as president. F. R. Herdman was elected vice-president and J. Gilbert Hickcox secretary and treasurer. This company states that it is compelled to run its works nights to fill all the orders received. In has recently furnished the printing press controllers and rheostats for the new *Germania* Building, of Milwaukee.

Business in the South and Southwest. W. Wright, manager of the Chicago Armature Company, in a recent business trip through the South and Southwest, found an improvement in the tone of business, from which he benefited to the extent of several large orders for refilling commutators for railway motors and also for rebuilding complete four 60-KW, 500-volt railway generators and rewinding fifteen W. P.-30 railway motor armatures. Mr. Wright anticipates a very busy season in the early spring.

Mr. L. E. Frorup, has resigned his position as general sales agent for Schiff-Jordan & Company, carbon manufacturers, and accepted a similar one with the General Incandescent Arc Light Company, of New York. Mr. Frorup will have entire charge of the sales department, with the details of which he is entirely familiar, having filled various positions with the latter company, the last of which was that of Chicago representative just previous to occupying the general sales agency of Schiff-Jordan Company.

Roth Brothers & Company, 30-34 Market Street, Chicago, state that they have received many large advance orders for fan motors. This company is at present running its shops to their fullest capacity, and if the energetic manner in which these gentlemen are pushing their goods is any indication, it is reasonable to assume that the Roth fan motor will have an extensive sale the coming season. A new catalogue has just been issued listing their fan motors. The New York Dynamo & Motor Company, 257 Broadway, New York, are Eastern agents for this company's fans.

The Phœnix Telephone Manufacturing Company, of Chicago, manufacturers and dealers in telephones and telephone apparatus, desires to contradict certain unfounded reports that have been in recent circulation, to the effect that it has disposed of its several switch-board patents to the Bell Telephone Company. On the contrary, it is still manufacturing under these patents and reports its output for the past three months to be larger than ever before for that period. The large increase in its orders has compelled it to enlarge its facilities to quite an extent and it is now able to fill orders on the shortest possible notice.

The St. Louis Electrical Supply Company, St. Louis, Mo., has reached the 25,000 mark on the sale of its carbon battery for 1897. This company, which is one of the leading ones in its line, has recently gone into the manufacture of telephones on an extensive scale. In order to show customers just what it makes in the way of telephones and telephone supplies, it recently issued a neat little catalogue which is nicely printed and handsomely illustrated with numerous half-tone cuts. Every one interested in telephone matters should send for a copy of this catalogue. It is mailed free of charge to anyone asking for it and mentioning the AMERICAN ELECTRICIAN.

The Southern Log, Cart & Mill Supply Company, of Mobile, Ala., while having a peculiar name, handles everything in the line of general machinery and construction supplies. Its trade is not confined by any means to Mobile and contiguous territory, as it has freight rates which enables it to compete with any city in the United States. Among the specialties are spikes, track bolts, fish plates, bar iron, etc. It manufactures the well known Salvator babbit metal and represents the Chas. Munson Belting Company, of Chicago, the New Jersey Car Spring Company, of Newark, N. J., and many other well known manufacturers in its line.

Electricity in Belts. In a recent circular of the Joseph Dixon Crucible Company, of Jersey City, N.J., it is related that some time since an engineer in a large factory called the attention of a visiting electrician to the electricity in a big driving belt, and was quite surprised when the expert informed him that the electricity was caused by the belt slipping. The expert added that it was simply a waste of power and could be prevented by applying Dixon's traction belt dressing, made by the Joseph Dixon Crucible Company, Jersey City, N. J. This dressing was applied and the electricity disappeared at once. Electricity in belts, it is added, is not only a waste of power, but is also an element of danger by fire.

The Chicago Rawhide Manufacturing Company, Chicago, finds at present a greatly increasing demand for rawhide pinions for geared electrical machinery. This company, which is the original maker of rawhide goods of all kinds, especially of pinions, has superior facilities for manufacturing, and its goods are shipped all over the world. The company is furnishing a number of electrical manufacturers with pinions, both cut and uncut. The special advantage claimed for the rawhide pinion is that it makes less noise and is more durable than steel. Besides, it is a non-conductor of electricity. The company reports that its trade in rawhide packing is at present on the increase, having special advantages for many kinds of service.

The Warren Electric Company, formerly of Chicago and New York, has located its plant at Sandusky, O., where it now has every facility for turning out work promptly. The works are equipped with fine machinery throughout and have been thoroughly overhauled and repainted wherever necessary, so that a most cheerful appearance prevails. Mr. C. C. Warren is well known as one of the pioneers in the electrical business, having sold and equipped many of the first electric lighting plants installed, especially in the West. The alternator which bears his name is in use in many plants throughout the country, and was designed by himself and son, Mr. H. B. Warren, who is associated with him as chief engineer of the company.

The Filer & Stowell Company, Milwaukee, Wis., manufacturer of Corliss engines and pumping machinery, reports an increased and improving trade. Among some recent sales it reports contracts for the installation of two plants of special interest, one for the new Alexian Brothers hospital, Chicago, the other for the Baraboo Gas & Electric Light Company, Baraboo, Wis. These plants are a new departure in direct-connected generators. Heretofore small units of from 30 to 60 KW have only been run either belted or direct connected to high speed engines. In these two cases, however, the dynamos are direct connected to slow-speed Corliss engines. Peculiar interest attaches to these, as they are the first installation of this type in the United States.

A. W. France, of Tacony, Philadelphia, reports having received an order from the Sayre & Fisher Company, Sayreville, N. J., for a large alternating and 500-volt direct-current switch-board to be equipped with his patent non-arcing switches. Also one from the Suburban Electric Company, of Tacony, Philadelphia, for an 8-circuit board for 2200-volt alternators, to be equipped with non-arcing switches. The Suburban Company made a very thorough test with these switches before placing its order, shifting very heavy loads from one machine to another without a sign of an arc, and have pulled the switches on dead short circuits without a spark. The France factory is also kept very busy filling orders for fuse boxes and grease cups, the demand being so great, that the factory is running night and day.

Partrick & Carter Company, 125 South Second Street, Philadelphia, Pa., has made arrangements whereby its well-known needle annunciators, bells, batteries and all kinds of supplies for hotel and house work can be obtained from the following electrical supply houses; J. M. R. Meikelham, New York City; Buerk Hardware Company, Chicago, Ill.; W. T. Osborn & Company, Kansas City, Mo.; A. S. Carter & Company, Denver, Col.; John M. Klein's Electrical Works, San Francisco, Cal.; Wybro & Lawrence Company, Los Angeles, Cal.; Salt Lake Electric Supply Company, Salt Lake, Utah; Montana Electric Company, Butte, Mont.; Wolfe Electrical Company, Omaha, Neb.; Electrical Engineering Company, Minneapolis, Minn.; Electric Supply & Construction Company, Savannah, Ga.; Harris & Williamson, Birmingham, Ala., Schminke & Newman, New Orleans, La.; Electrical Supply Company, City of Mexico.

Voltage Regulation. Among the more recent commendations received by the Belknap Motor Company, of Portland, Me., concerning the Chapman voltage regulator is one from the Kensington Electric Company, of Philadelphia. In acknowledging the receipt of a second controller, Secretary Wilkinson states that to his mind it is a necessary adjunct to the successful operation of any plant with variable load. He adds that his company is running motors in conjunction with lights, and that the starting and stopping of the former has had no appreciable effect since installing the Chapman regulator. Among the recent orders received for the Chapman regulator have been from the Edison Electric Illuminating Company, of Topeka, Kan., the Marietta (O.) Electric Company, and the Calumet Smelting Company, of South Lake, Linden, Mich. An agent in Pennsylvania recently forwarded orders for ten regulators which be had placed.

The Electrical Engineering Company, of Minneapolis, is carrying the finest and largest line of electrical supplies in the Northwest in its warerooms at 311-13 Second Avenue, South, where it has commodious quarters. Among the several specialties which this firm has recently put upon the market is a new portable desk telephone. The Northern Pacific Railway has just ordered some two dozen sets of this telephone, and expects to order as many more for use in its St. Paul offices. This company has just equipped a 150-line board exchange for Northfield, Minn., also one for the Northern Pacific Railway in St. Paul. It has in stock at present about 25,000 Buckeye lamps, enough O.K. weather-proof wire to girdle the entire Northwest, and is just filling an orner for 125 Manhattan incandescent arc lamps for the Wyman Partridge Building in Minneapolis. The large stock and the general air of prosperity and activity which characterizes this company would indicate that it is securing a generous share of the rapidly increasing business in the Northwest.

Electric Haulage.—The Woodward mine of the Delaware, Lackawanna & Western Railroad at Kingston, Pa., is about to be equipped with electric haulage by the General Electric Company. The generating plant will consist of one 165-KW dynamo directly connected to an American Ball engine. The circuits will be three in number. The first will pass down a vertical shaft 725 ft. deep and will operate one ten-ton locomotive in the Cooper vein. The two others will be carried down another vertical shaft 1026 ft. deep to operate two ten-ton locomotives in the Red Ash and Baltimore veins. These locomotives will be equipped with two 40-HP G. E. motors, and will handle trips of loaded mine cars each loaded car weighing about 4½ tons. It is estimated that this installation will show in operation a net saving of 29.5 per cent. over mule haulage, including a large reserve for depreciation, interest and fixed charges. The total output of these three locamotives will be about 3800 tons per day, and the total length of trolley wire in the gangway will shortly reach 4½ miles.

The Light for the Wheel. Of recent electrical inventions none are of greater interest than the bicycle electric light, especially at this season, with the bicycle claiming the attention of all who ride. To obtain a light that will not jolt out has been the aim of lantern makers since the advent of cycling. To jolt and depolarize the primary battery has been the aim of electricians. With a perfect jolter like the bicycle, the primary battery works to perfection, and the aim of the electrician is accomplished. One of the hardest workers in this branch of electrical science is Mr. Albert C. Fletcher, of Cleveland, O., the inventor of the necktie light, pocket battery, etc. In this battery the generation of gas is overcome and leaks are unheard of. Those who have worked in this line will appreciate what has been accomplished. How bicycle riders appreciate the Ohio bicycle electric light can only be realized by riders who have attempted to keep lighted an ordinary lantern on their wheels. All who are interested can obtain detailed information concerning the above device, by addressing the Ohio Electric Works, Cleveland, O.

American Electrician.

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THE BROOMHILL ELECTRICAL INSTALLATION.

BY SIR DAVID SALOMONS, BART.

TO describe fully the electric installation and the various uses for which electric energy is employed at Broomhill, would occupy more space than could fairly be allotted to any one article in a technical journal, while it would probably weary the reader. A brief outline of the history of the plant, and a general survey, will therefore suffice for those interested in private installation work.

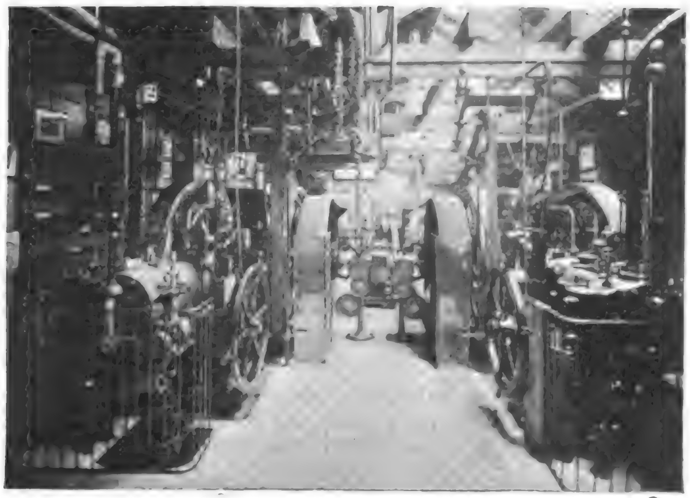
The electric light was first employed at Broomhill, which is situated nearly three miles from Tunbridge Wells, England, in the year 1874, in connection with the small workshop in which the owner employed his spare time, and he lays claim to having been the first to use the electric light in a private house on a practical scale in England.

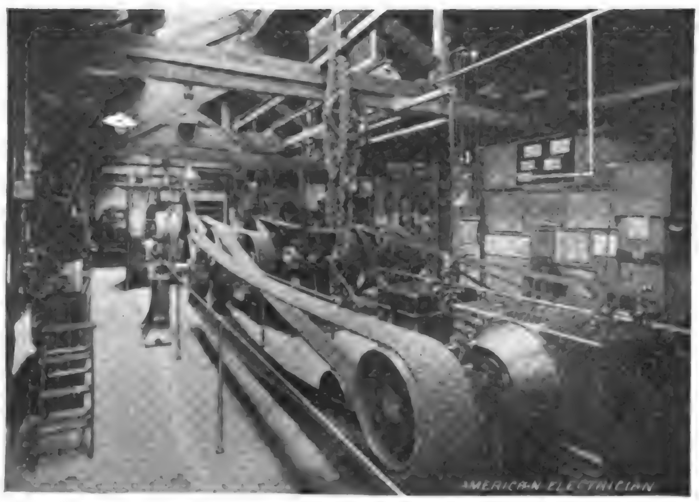
The workshops and laboratories have been rebuilt and enlarged from time to time, till they now occupy a building considerably larger than the dwelling house to which they are attached.

The workshops contain every tool, whether of the machine type or for hand use, necessary for producing all kinds of work large and small, and the laboratory, probably, is the most complete of its kind of any in England.

The electric light and power installation is in a separate building adjoining the workshops. It has seen at least six complete transformations. First, the installation was erected for sixty 20-CP incandescent lamps without accumulators, and it has continued to grow until it reached its present state (which will be described later) in the year 1884. The only change since that time has been to supplant the steam engines by gas motors in consequence of the price of coal having gone up and that of gas being lowered.

At the present day, when electrical engi-





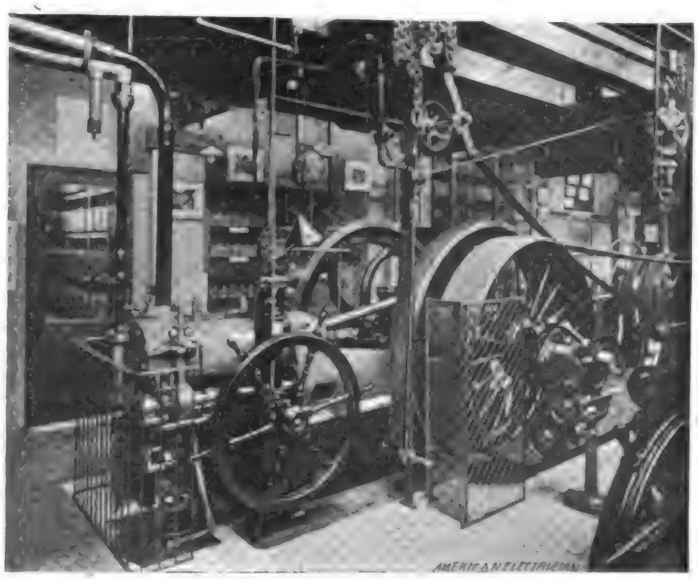


FIG. 1.—GENERAL VIEW OF ENGINE HOUSE.
FIG. 2.—GENERAL VIEW OF ENGINE HOUSE, SHOWING DYNAMOS.

FIG. 3.—ACCUMULATOR HOUSE, SHOWING CRADLE FOR MOVING HEAVY CELLS.
FIG. 4.—GAS ENGINE, SHOWING ELECTRIC STARTING DEVICE.

BROOMHILL INSTALLATION.

neers are to be found in every village, and all possible methods of working are known to those engaged in the industry, it is hard to make people now concerned in electrical work realize the obstacles which the pioneers had to encounter.

FIG. 5.—SPECIAL ACCUMULATOR BOARD, SHOWING SWITCHES FOR PLACING EXTRA CELLS IN PARALLEL OR SERIES.

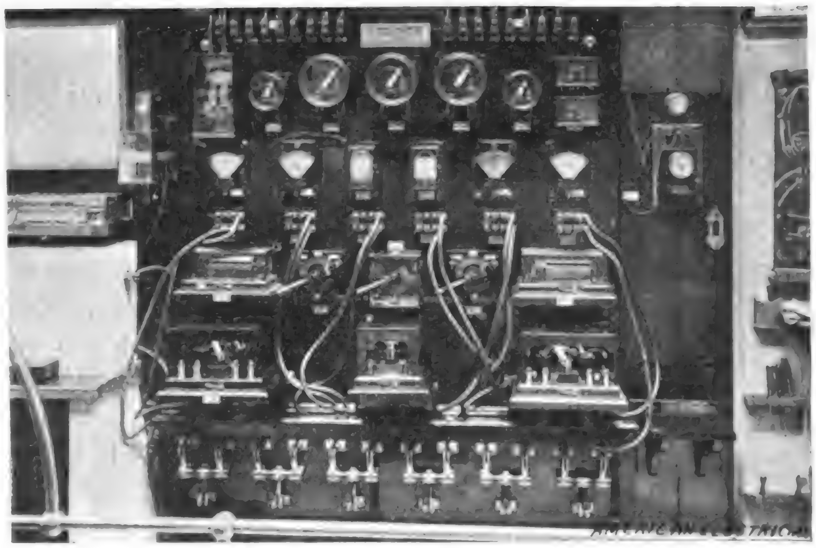


FIG. 6.—GENERAL SWITCH-BOARD IN ENGINE HOUSE.

A few instances may be given to illustrate the difficulties which existed. Those days, though not far distant, were a period of complete ignorance in these matters. All the details of working and the characteristics of dynamos supplied at that time, were left entirely to the purchaser to discover for himself. The switches were of the most primitive order, and completely unsuited for heavy currents, while their mechanical construction was such that frequent renewal was necessary. The accumulator was sent out with practically no instructions, and such instructions as were supplied were completely erroneous according to our present knowledge. Automatic apparatus was a thing unknown.

It was, consequently, necessary for the owner of Broomhill to work the whole matter out for himself from beginning to end, and it is not unnatural, therefore, that he should claim to have devised many forms of apparatus and methods of working which are now in general use, because the first reasonably intelligent man engaged actively in a new field of work was bound to discover many of the devices and methods which those who followed would take advantage of.

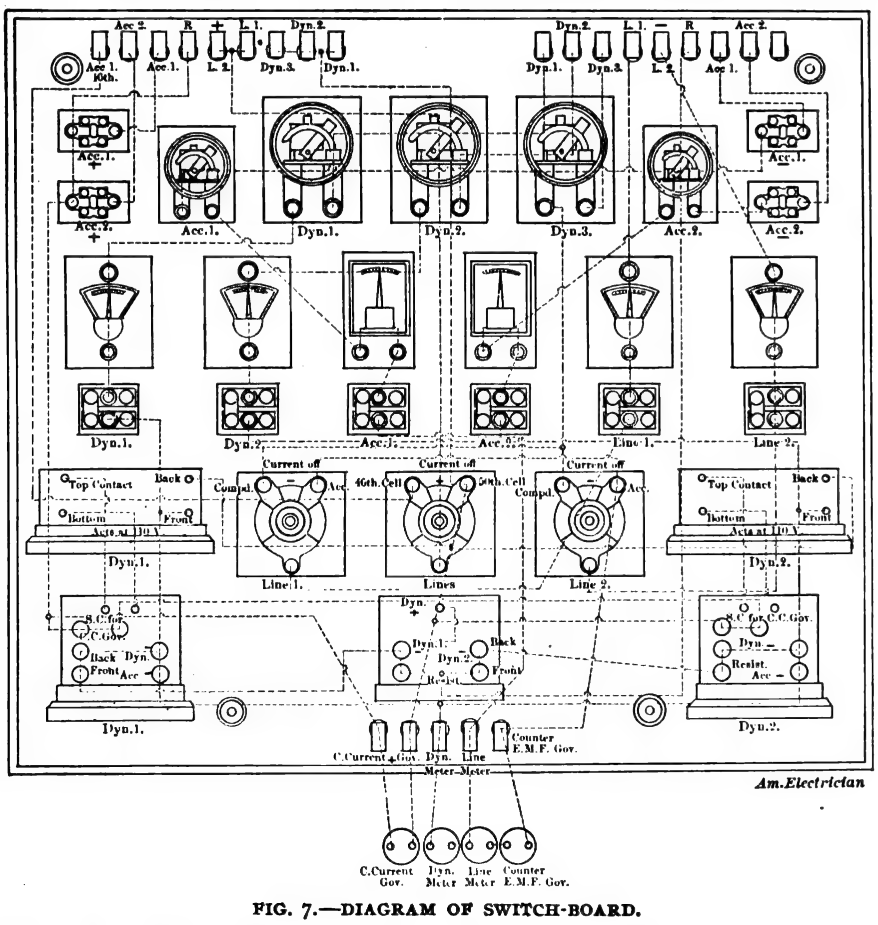


FIG. 7.—DIAGRAM OF SWITCH-BOARD.

To give an instance of a few of the devices which were made for working the installation, it may be pointed out that the present form of arch switch, now so universally in use, was first made at Broomhill. So also was the automatic apparatus for charging accumulators. Likewise, the method of raising and lowering the E. M. F. of shunt-wound dynamos by inserting resistances in the winding of the magnets; the whole of the present methods of treating accumulators, and hundreds of other matters were investigated and brought to a successful issue in this installation and in its laboratory. It must not be imagined that all results were obtained at the first trial. Endless pieces of apparatus had to be made, and experiments performed, before the results were satisfactory.

The owner had a great belief in using 100 volts in preference to 50, which was in vogue at that time. To obtain this voltage, it was first necessary to employ two dynamos, each giving 50 volts in series, as no 100-volt machine could be purchased in those days of a satisfactory nature.

All these labors, however, have not been wasted, for since 1884, the installation has been rendered entirely automatic, no switches in the engine-house being required for daily working, and there has been no breakdown from that day to this. The accumulators, which at first gave out after a few months' working, now last at least five years without showing much signs of wear and tear.

The present installation consists of two shunt-wound dynamos, each of which gives a maximum current of 150 amperes at 150 volts, a compound-wound dynamo for a current of 200 amperes at 110 volts, a compound-wound dynamo giving a current of 90 amperes at 50 or 100 volts at pleasure, and lastly, an alternator for a current of 60 amperes at 100 volts. There are two gas engines, each working up to 33 I. HP. These are started by a special device by means of a small electric motor.

There are two secondary batteries, with 56 cells in each battery, capable between them of giving a current of 100 amperes for ten hours. There is also a small accumulator of

25 cells, which is employed to lower the E. M. F. on the lines when the batteries are being charged. These cells are termed the counter E. M. F. cells.

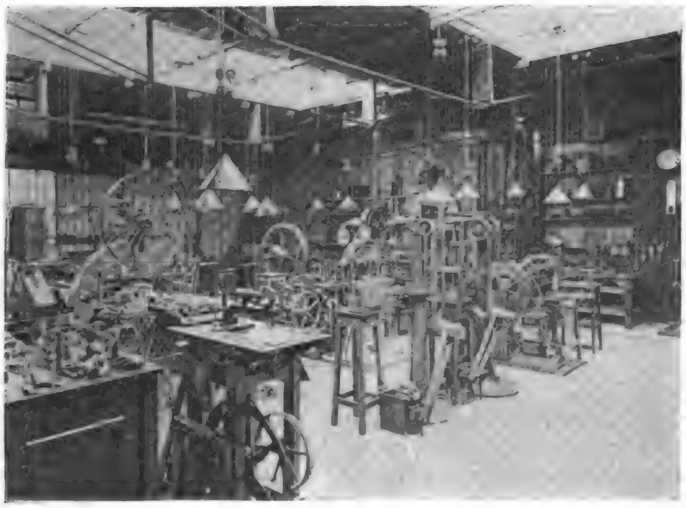


FIG. 8.—GENERAL VIEW OF WORKSHOP.

FIG. 9.—SMALL WORKSHOP.

The switch-boards may be divided into four sections, two of them being automatic. The large board is the general key of the system, and has placed upon it the various automatic devices, indicating instruments, magnetic and fusible cut-outs necessary for the system. Another board carries two automatic arrangements, one by which the charging current to the battery is kept constant by the insertion of more or less resistance in the shunt winding of the dynamo magnets, and the other an automatic governor for placing more or less counter E. M. F. cells in the house circuit as required, so that the pressure is kept constant at 100 volts in the house.

Any attempt to describe in detail the various devices for making the installation completely automatic, would be too lengthy for a general description, but the illustrations which accompany this article give a fair idea of some of the arrangements.

The motor which starts the gas engines is a special device, enabling it to start free, and only to commence doing work when the speed is up.

The number of lamps now installed in the house, workshops, laboratories, theatre, stables, and other buildings, considerably exceeds 1000 16-CP lamps, and some 10 or 12 arc lamps. The largest number in general use would not exceed 200 glow lamps, and 4 to 6 arc lamps.

Fig. 1 gives a general view of the engine house. It will be observed that there are two gas engines, the moving parts of which are protected by rails and wire guards. There are also to be seen the electric starters and the special arrangements for throwing the clutches in and out of gear. The latter are in the center of the picture.

As a rule, the man who puts on the clutch faces it, and if he were to slip, there would be a possibility of his head or arms becoming entangled in the spokes of the pulley. To avoid such a mishap, a worm wheel is employed which places the attendant at right angles to the plane of the wheel. The disadvantage of this system is that the worm is either too high or too low for convenience. In this instance cog wheels are employed in order to bring the handle to the most suitable position. Over the cog wheel which carries the handle, a shield is fixed, somewhat larger in diameter than the cog wheels, the object of which is to prevent any chance of the fingers being caught between the cogs.

Much of the success in running is due to the special arrangement employed for putting the clutch on and off. The nicest possible adjustment can be obtained by the worm gearing, and the attendant can move it from the most convenient position to himself and with the greatest of ease. The clutch is of such a character that it can be lubricated, and therefore be allowed to slip in any required degree. The result is that an absolutely steady E. M. F. can be obtained from the gas engines, it being only necessary to move the clutch to such a position that sufficient power is given through it, and yet a slip allowed to keep the voltmeter needle steady. There is no loss of power by this method because the fly-wheel stores what might be imagined is lost.

Fig. 2 is a view of the engine house from the other end showing some of the dynamos. It will be observed that on the wall there is a plan of the dynamos, which has for its object to enable the attendant, when making any changes on the switch-board, to see the position of any machine, which it is not easy otherwise to observe, as the belting somewhat obstructs the view.

Fig. 4 is a view of one gas engine, and is given in order to show more clearly the clutch arrangement which has been described, and the electric starter.

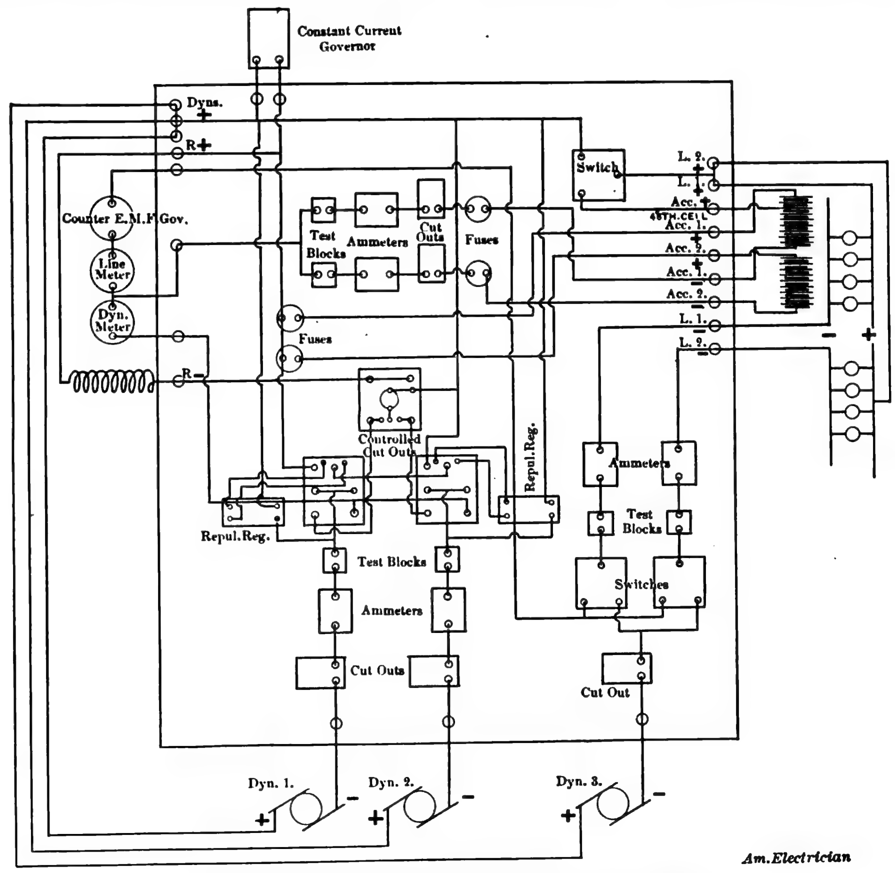


FIG. 10.—GENERAL DIAGRAM OF INSTALLATION.

Through a glass door the accumulator room is seen.

The method of starting the gas engine has proved so convenient, that a more detailed description may prove of some service to the reader.

In a small installation, the gas engine can be set in motion by means of the dynamo. This, however, cannot be done in the case of large engines, as there would be a risk of damaging the cells. Before the arrangement now in use was inserted, two men exerting all their power were necessary to start either engine. As the effort was so great, four men were generally put to the work. At the present time a child can start the whole machinery in motion with ease. In Fig. 1, between and beyond the clutch gear, can be seen the motor which does the work. To avoid the necessity of a motor for each engine, a short counter-shaft is employed, and it will only be necessary to describe the arrangement for one engine as it is the same for the other.

A belt passes over the pulley on the counter-shaft, thence to a pulley seen in Fig. 4, which is at some distance above one of the fly-wheels. The belt then proceeds downwards over the roller near the floor and back to the counter-shaft. This belt is loose so that the fly-wheel turns without rubbing it when the roller (which is capable of being slid up and down a fixed rod) is in the position shown in the cut. Let us now start the engine. Every valve is left at all times adjusted ready for starting. It is therefore only necessary to turn on the meter tap; the sliding roller (which is counterpoised) is raised so that the belt swings free and touches the fly-wheel loosely, the switch above what appears to be a steering wheel, is moved and the motor started. When the speed is up, the starting wheel is turned, the rope from this is attached to one of the lever arms which carries the pulley above the fly-wheel. Consequently the belt is gradually tightened and about one-third or more of the fly-wheel is gripped by the belt. It is only necessary to turn the starting wheel and hold it until the engine runs. On leaving go of the wheel the rope unwinds itself, the motor is then stopped, and the sliding roller pushed down. Nothing further has to be done. The whole operation takes but ten to twenty seconds. It is, of course, assumed that the ignition tube burner has been lit before the commencement of the operations.

Over the chimney of this apparatus will be observed a pipe with a funnel end, its object being to carry off the gas fumes. This pipe becomes very hot, and a little way above the funnel end a piece of wood surrounds it for handling, and higher up is a ball-and-socket joint. Consequently, when required this pipe may be pulled out of the way to see what is going on; also for the purpose of lighting the burner. The short piece of pipe with a tap at the end leading into this ventilating tube is placed there to catch any condensed water. Without this provision, there would be a risk of the condensed vapor extinguishing the light. Where the tube meets the open air, a special form of cowl is fitted, to prevent the possibility of a back draught which might extinguish the burner. All these matters may appear details, but they are by no means unimportant. Much of the gun-metal and brass work in the room began to be injured by the gas fumes, and this ventilating arrangement has entirely cured the disease.

Under the engine governor there is to be seen a slide. When the engine is running steadily, the slide after, say, two minutes, is pushed in, the result being that if one or two explosions are missed, the engine is not pulled up; in fact, since this addition it has been possible to leave the engine running the whole day without attention. It might be enquired why should this arrangement not be permanent? The reason is that the governor has to assume a different position for starting, at the time when the lever is moved for non-compression; but when running under normal conditions should the governor balls drop below a certain point, no recovery is possible as the gas cam will no longer be actuated, and this slide prevents the possibility of such an occurrence.

The funnel-shaped pendant lamp, which is seen above the engine, is one devised by the owner to meet a want, and it has been extensively used on account of its convenience. The shade can be raised and lowered, and placed at whatever angle may be desired; and in whichever direction it may be placed it will there remain, and can even be turned to give a light directly upwards. In the engine house and workshop, these lamps take the form seen in this picture, but for use in the house, ornamental designs are introduced to suit the furniture in the rooms where they are placed.

Fig. 6 gives a general view of the switch-board. The two center ammeters are in connection with the two accumulators. The advantage of using two accumulators in the place of one cannot be over-rated. It can be observed whether one accumulator is charging or discharging more rapidly than the other. Hence, the battery which is not doing its work fairly is located. Again, in the event of repairs being necessary, the current is not cut off, care only being necessary that the accumulator requiring attention shall not be taken out of the circuit at a time when the demand is such that two batteries are necessary.

The instruments seen at the lower part of the switch-board are automatic devices to enable the running of the installation without any switch being manipulated by hand, and no matter which dynamo is run. The upper part of the board carries the fuses and magnetic cut-outs. The lowermost lines of D. P. switches are in connection with the loose cables (which need not necessarily be left on the board), and their use is to enable connection to be made between the ammeters and Lord Kelvin's standard balance, which is seen on the left hand side. The arrangement is such that tests can be made without cutting the circuit.

The little indicator at the right hand side, and not upon the switch-board, is an insulation tester devised by the owner and works very well. The large label placed above the board is simply a guide to the attendant. He divides the units used by seven, and this gives him the number of hours he has to run.

Fig. 15 shows what may be termed a series of little switch-boards side by side. Commencing on the left, where the bell forms part of the arrangement, this is used for the following purposes: The bell will ring for the maximum and minimum temperature in the engine house, indicating either that frost has entered it, or acting as a fire alarm. When the lowermost dial is set going by its clock-work, the bell rings

FIG. 11.—THEATRE AND LABORATORY, SHOWING STAGE AND PROJECTION SCREEN.

FIG. 12.—THEATRE AND LABORATORY, SHOWING LABORATORY END, LANTERN GALLERY AND ORCHESTRION.

once every minute and is useful for taking speeds. The next switch-board applies solely to the arc lamp on the tower.

The adjoining board is for testing purposes, *i. e.*, that in the engine house various currents may be taken equivalent to any given number of lamps lighted in the house and elsewhere. The use of this is to see how the dynamos and cells behave under varying conditions, and the arrangement was originally necessary for setting the apparatus and arranging the speeds. The next switch-board illustrates the counter E. M. F. governor, and the apparatus by its side is that portion which works the large circular switch. This is entirely automatic and any change in the E. M. F. in the engine-house, whether the engine is running or standing, is brought to the normal 100 volts in the house automatically.

FIG. 13.—LABORATORY END OF THEATRE.

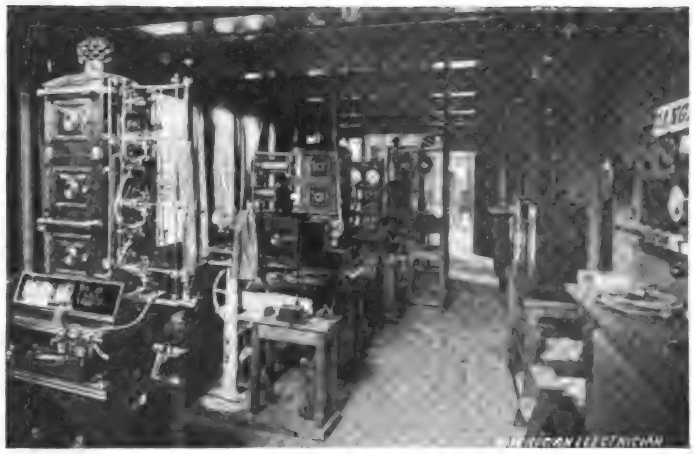


FIG. 14—PROJECTION LANTERN IN GALLERY OF THEATRE.

The next apparatus, to the right, is the constant-current governor. This works only when one or both of the engines are running, and keeps the current to the cells at a constant value. Then come the meters for measuring the units. It will be observed there is a meter for the stables. This is merely inserted to see that there is no waste in that department. The two essential meters are those marked "dynamo" and "all lines." It is the duty of the attendant to observe that the dynamo-meter reading shall always be 10 per cent. higher than the "all lines" meter reading.

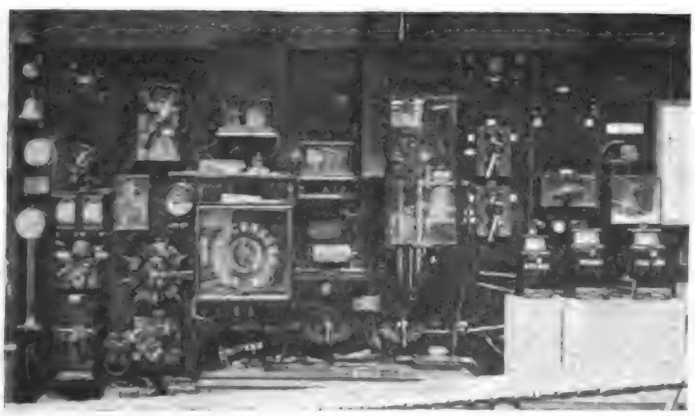


FIG. 15.—CONSTANT-CURRENT AND COUNTER E. M. F. GOVERNOR IN ENGINE HOUSE.

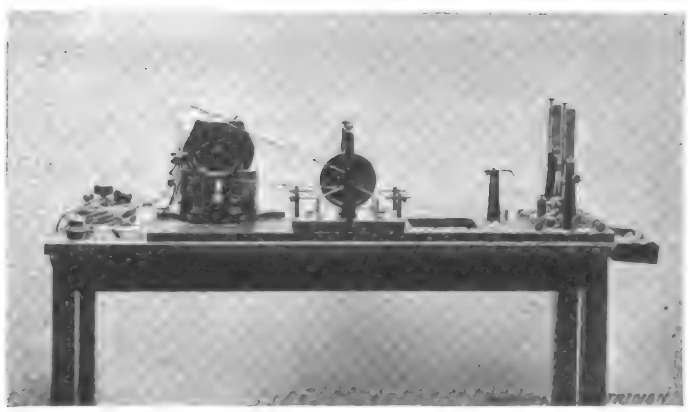


FIG. 16.—SPECIAL APPARATUS FOR MEASURING SPEED OF LIGHT, ETC.

Fig. 7 is a diagram of the switch-board and Fig. 10 a general diagram of the whole installation.

Fig. 9 shows the little workshop adjoining the engine room. Besides this shop, there are two other rooms used for stores and another one for mixing acids. In this workshop, behind where the clock hangs, stand the large tanks containing the water which cools the cylinders of the engines. The wooden stand with trays upon it is an accumulator (almost completed) of 500 cells, with a charge and discharge rate of one ampere. There is another battery like this finished, so that the two will give an E. M. F. of 2000 volts and they are to be employed in connection with vacuum tube work.

On the other side of the room, there is to be found a small switch-board, shown in Fig. 6.

The two large switches are for placing the extra cells parallel or series at pleasure, thus avoiding what are usually idle cells. Below these are D. P. switches simply for cutting the circuit of one or the other accumulator. The groups of fuses are in connection with the counter E. M. F. cells, and are not essential, but they are inserted as a precaution in the event of a workman touching two terminals on the governor at one time with a spanner, which would injure the apparatus very considerably if there was no protection.

Fig. 3 gives a general idea of the accumulator house and the method by which one man can move a cell unaided, although each one weighs, approximately, 2 cwt. The owner devised the arrangement in order that one man could attend to the whole installation without assistance. This consists of a universal traveler of the usual kind, which carries a cradle. The prongs of the latter are pushed below the board on which the cell to be moved stands. The counterpoise is then turned upon a steep screw to the position shown. The cradle is slightly raised, and the pot can be withdrawn and moved to any desired place.

The method so commonly adopted of bolting together the lead tags of one section to the next, or of soldering them together is avoided by a very simple means. Strong cast-iron clamps pinch the lead strips together whereby a large contact surface is offered. In practice, the clamp, whatever ordinary metal is employed, is soon eaten away, the lead remaining intact. To cure this, a very simple device has been resorted to. Some ordinary sheet zinc is cut into strips, and then again cut up into short lengths. One of these is bent around the lead tags over which the clamp is slipped, so that the zinc stands between the lead and the iron. This metal is the one that will corrode and not the other two. Moreover, the zinc under these conditions becomes destroyed very slowly and it is only necessary once in two or three years to replace it whereas the iron, 1 in. thick, used to be eaten away in the course of a few months. The right and left shelves carry the two batteries. Those seen at the end of the room are the counter E. M. F. cells.

Further description of the engine house and its accessories, though possibly interesting to some, would be wearisome to the general reader. We will, therefore, turn to the

workshop proper, situated close by, and the other places which are in connection with the house.

Fig. 8 gives a general view of this workshop. The machines here cover all trades, and each one is worked by its own electromotor. The room is lighted generally by two 100-CP and one 200-CP lamps, and every machine has one or more of the special lamps, of which so many are seen in the picture. There is nothing very special to describe in regard to the machinery beyond what the illustration shows. On the other side of the workshop, not seen in the view, are large benches for fitting and hand work. Adjoining this shop is a small one used exclusively for carpentry, and adjoining this room is a forge. On this floor there is also a study, a secretary's room, a packing room and a small electrical laboratory. On the first floor is a large studio, with three dark rooms, as well as a chemical laboratory.

On the ground floor, all in communication, is the theatre, with dressing rooms and a large stage, with all possible accessories, suitable for stage plays, lectures and other purposes. The wall at the back has a beautiful white surface, about 24 ft. square, to form a screen for optical projections. Cabinets are placed around the ground floor and galleries, for the apparatus, a scientific library and other matters. Part of the building is seated for 150 people, the remainder being devoted to a laboratory. The dimensions of this room are 80 ft. long by 40 ft. wide and 33 ft. high. The general appearance of the theatre looking towards the stage is shown in Fig. 11, and Fig. 12 is a view taken from the stage. The gallery to which the clock is attached is the lantern gallery. The second gallery, above this, carries various musical instruments, worked electrically, and in the center can be seen the orchestrion.

Fig. 13 is the end of the theatre used as a laboratory, and here can be seen in the center the Broomhill magnet with which so much work has been done.

Fig. 14 shows the lantern gallery, and the door, which is open at the end, enters the studio. The first lantern to the left is a lime-light triple, then comes the theatrograph, next the special form of electric-triple lantern, designed by the owner, which is quite revolutionary in design. By the side of this is seen the switchboard for working this lantern. Beyond is another lantern not so well seen, used solely for scientific work. This lantern, with its apparatus, is probably the most perfect in every way that has yet been constructed. There is no phenomenon in polarised light, and scarcely one in all branches of physics, which cannot be illustrated upon the screen by its use, and in consequence this apparatus has been invaluable.

The whole of the rooms are heated by hot water and there is a total absence of gas, except for laboratory purposes. The use of gas is restricted to such places where damage is not likely to occur by the presence of its fumes.

In Fig. 16 is shown a piece of apparatus of considerable interest. This is a revolving mirror which can be kept unceasingly at work at tremendous speeds and without vibration. There has been great difficulty experienced in constructing such mirrors. The majority of those in use can only be kept in motion for short periods and require a large amount of attention. In this case the mirror is made of polished steel and has six faces. In the illustration, this is placed at the right hand and horizontally. The two cylinders above are oil feeders, so that the turning portions are moving in running oil. At the left is seen the motor and in the center the counter-shaft. The whole apparatus is supported on a cast iron base. The mirror can be revolved at 46,000 to 48,000 times per minute without risk. The bearings of the counter-shaft as well as those of the mirror are supported by cotton ropes, the tension of which can be adjusted by means of mill-headed screws. These ropes destroy all vibration, so that even when the mirror is running at its full speed, the table, although supported on castors, is free from tremor. The arrangement is such that the mirror, when desired, can be placed in a vertical position, for which purpose the support which appears to have no object for its existence comes into use. A little wooden pillar, by the side of the mirror, carries a slip of paper which is struck by a balanced pin passing through the mirror spindle. Its speed can therefore be ascertained by means of the musical note or rather the "whistle" set up.

The apparatus, simple as it now appears, required all the resources of the Cambridge Instrument Company, who made it, as well as of the owner, to overcome difficulty after difficulty which presented itself, and more than two years elapsed before the results were quite satisfactory. The apparatus is started and regulated close by the mirror where the experimenter would naturally stand, but this part is not shown in the photograph.

There are a large number of other pieces of apparatus, of special construction, and a unique collection of crystals, suitable for the polariscope and other purposes which would only interest the specialist, and therefore need not be described in this article.

The writer trusts that, in meeting the request of the editor, to give a general description of his installation and laboratories, he has carried out the object without exceeding the fair limits of space which should be accorded to such a subject.

Who Invented the Telephone?

In an affidavit submitted at a hearing before the Secretary of the Interior on Oct. 31, 1885, on various applications made for leave to bring suits in the name of the United States to cancel the Bell telephone patent, Thos. A. Edison declared that the inventions described in his English telephone patent of July 30, 1877, "were made by me in 1875, the experiments continuing from that time right along, and culminating in the carbon telephone now universally employed." In the same suit Prof. Elisha Gray presented an affidavit declaring that he filed a caveat on Feb. 14, 1876, on an electric speaking telephone, the same day as Prof. Bell, and that the latter "having obtained my secrets, claimed my discovery as his own, and by this means got the credit of my invention." In the same suit affidavits were filed by other alleged inventors of the telephone.

DYNAMO CHARACTERISTICS.

BY PROF. WILBUR M. STINE.

In order to intelligently study the characteristics of the dynamo, it will be necessary to consider the effect of armature reaction, and the causes for the departure of actual curves from their theoretical outlines.

Armature Reactions.—With armatures of the closed coil type, the brushes bear on the commutator at the neutral points; these lie in the commutation plane which passes through the axis of the armature at right angles to the magnetic axis of the fields. In a perfectly symmetrical armature the current divides equally at the brushes and passes through the coils in series on each

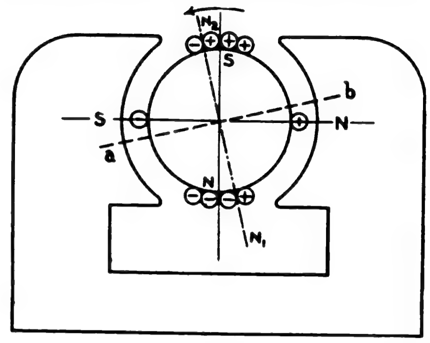


FIG. 1.—ANGLE OF LEAD DUE TO ARMATURE CROSS-TURNS.

side. These coils being windings about an iron core excite, the core into an electromagnet of considerable power. The lines of force thus set up in the armature by the current in its windings constitute a magnetic field whose direction is at right angles with the magnetic flux of the dynamo field. The result is a "skewing" of the dynamo field, and the brushes must be moved forwards to the now displaced neutral points.

This angular displacement of the brushes, which in the dynamo is in the direction of rotation, is called the angle of lead of the brushes. The predetermination of the angle of lead is rendered difficult by the unequal reluctances of the two magnetic fields. The relations of the angle of lead are shown in Fig. 1; the neutral points are in the line N_1-N_2 while the dotted line, *a b*, shows the

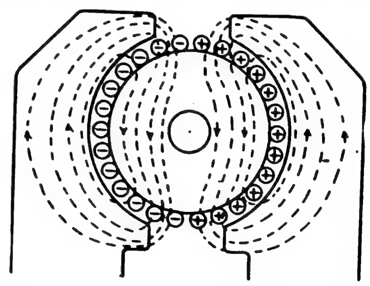


FIG. 2.—MAGNETIC CIRCUIT OF ARMATURE CROSS-TURNS WITH DYNAMO FIELDS UNEXCITED.

direction of the dynamo field has been displaced forwards by an amount equal to the angle of lead. The deflecting ampere-turns due to current in the armature coils are known as "cross-turns." These have no direct influence in either weakening or strengthening the field. Owing to the forward displacement of the armature field, it is no longer symmetrically placed with reference to the pole pieces. Its lack of symmetry varies with the amount of the angle

of lead. The armature conductors on both sides lying within the angle of lead, sustain a new relation to the dynamo field; they are not in position to "skew" the field, and are not to be considered as cross-turns; their effect is to directly weaken or demagnetize the field and from such are called "back-turns."

A reference to Figs. 2 and 3 may make the distinction clear. In Fig. 3 the line, *P P*,

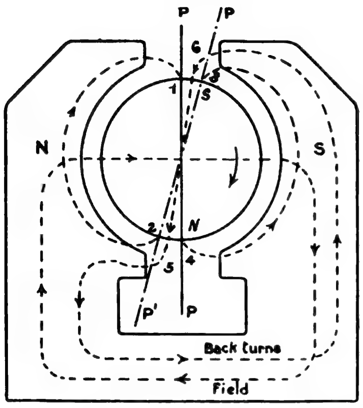


FIG. 3.—SHOWING BACK AND CROSS TURNS.

is the theoretical neutral plane, while, *P' P'* is the actual running plane of commutation for full load. The lines of force on the armature between the points 1 and 2 complete their external paths through the iron of the pole piece, *N*, while those between 3 and 4 pass through the pole piece, *S*. To these lines is due the angle of lead, and they are produced by the cross-turns of the armature.

At the following pole tips they are in line with the dynamo field and strengthen it, while at the entering tips they are opposed to the field and weaken it by the same amount, and as a rule do not alter the E. M. F. generated by the conductors. But the lines from 5, due to the conductors between 2 and 4, and 1 and 3, selecting the paths of least reluctance, pass into pole piece, *N*, and around the frame, and coming out from the other pole piece, enter the armature again at (6). Upon tracing the direction of these lines, it is seen to be opposed to that of the field.

In effect, the field is demagnetized to the extent of the number of such lines. The path of these lines through the core and field has essentially the same reluctance as that of the field itself, and an ampere-turn on the armature lying within the angle of lead will practically neutralize an ampere-turn of the field winding. By calculating the back ampere-turns the demagnetization of the amature at full load may be compensated for by giving the series ampere-turns an equal value.

On the drum armature there are two conductors to a turn, and the current in any conductor is one-half the total armature output. If *S* be the number of conductors and *I*, the total current, the ampere-turn due to this armature will be $\frac{I\,S}{4}$. The back turns are determined from the ratio of the angle of lead to 180 degs. Call the angle of lead *a*, then

$$\text{Back-turns} = \frac{I\,S}{4} \times \frac{a}{180^\circ}$$

An example of such calculations is the following: Number of armature conductors, 240; current at full load, 400 amperes; angle of lead, 15 degs.

$$\text{Armature amp.-turns} = \frac{400 \times 240}{4} = 24{,}000$$

$$\text{Back-turns} = 24{,}000 \times \frac{15}{180} = 2000$$

There are then out of a total of 24,000 armature ampere-turns, 22,000 cross-turns, and 2000 back or demagnetizing turns.

External Shunt Curve with Self-Excitation.—The data for this characteristic are given in Table, and the corresponding curve is illustrated in Fig. 5. This particular curve was obtained from the 4-KW 110-volt dynamo already described. The connections are clearly dictated in Fig. 4. During such a test the speed should be kept constant; the regulating rheostat, being set to give normal voltage on open circuit, should not be moved during the test. As the name of the curve suggests, the field is maintained by the shunt coils, the series

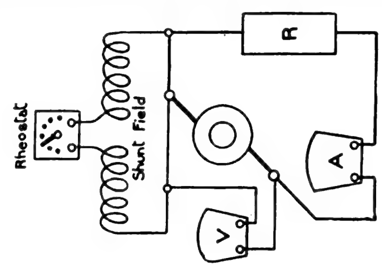


FIG. 4.—CONNECTIONS FOR DETERMINING EXTERNAL SHUNT CURVE.

winding being disconnected and the dynamo operated as a simple shunt machine.

EXTERNAL SHUNT CURVE.

Volts	Amperes	Volts	Amperes	Volts	Amperes	Volts	Amperes	Volts	Amperes
110	0.	58	10.3	3.5	4.9	15	3.95	53	6.29
109	1.	39	10.1	4.5	4.69	16	4.05	56	5.8
108	1.48	32	9.6	5.5	4.49	17	4.1	65	5.2
107.5	1.95	30	9.4	6.5	4.38	18.25	4.29	69.5	5.5
106.5	2,88	25	8.9	6.7	4.29	20	4.38	75	5.3
104	4.57	22	8.58	7.75	4.2	21.25	4.4	80	5.38
99	5.9	20	8.49	9	4.15	23.5	4.7	85	4.15
95	6.91	18	8.2	9.75	4.	26	4.89	89	4.3
90	8.26	14.5	7.89	10.25	3.92	29.5	5.03	95	2.61
80	8.61	9	6.89	11.25	3.75	32	5 2	100	2.72
75	9.55	6	6.15	11.75	3.9	35.75	5.3	107	2.1
70	10.52	4	5.7	12.5	3.97	43	6.1	112	1.08
65	10.49	2	5.25	14	3.91	47	5.9	115	.05

In the scheme of connections, *R* is a variable resistance, in this case a rack of incandescent lamps; the resistance should have a carrying capacity equal to the normal output of the dynamo, and be capable of a wide range of adjustment, a range which may readily be determined by an inspection of the data in the preceding table. The curve illustrates both the peculiarities of the self-excited shunt dynamo and the demagnetizing effect of armature reaction.

It will be noticed that the curve slopes uniformly until an output of 10.5 amperes is reached. As this slope is a regular curve and not a straight line, it shows that two variable causes are at work to decrease the E. M. F. of the dynamo. One of these is the demagnetizing back turns; as the E. M. F. falls off from this cause, the current through the field weakens proportionally, and contributes its share to decrease the E. M. F. The current of 10.5 amperes may be termed the critical current for this dynamo, for if the external resistance be further decreased the current *decreases*. The knee of the curve marks this critical point.

The resistance was decreased until the current reached 5.25 amperes with an E. M F. of 2 volts. This bending backwards of the curve may be explained by excessive armature reaction, the field being weakened at a proportionally greater rate than the decrease of external resistance. The current of 5.25 amperes at 2 volts being obtained, the external resistance was gradually increased, with the result that the curve of ascending voltage closely resembled that of the descending. It is important to consider the effect of opening the external circuit at any of the lower E. M. F. values; suppose the circuit to be opened with 8 amperes at 17 volts; the brush E. M. F. would at once go back to open-circuit value, which would be nearly 110 volts. It is obvious that if the circuit were then closed through this resistance of 2.1 ohms. a current of over 50 amperes would result, endangering the ammeter in circuit. For such reasons, those essaying the test should make it a continuous one, and avoid opening the circuit at any point.

An important conclusion may be derived from this curve. The fact that the critical

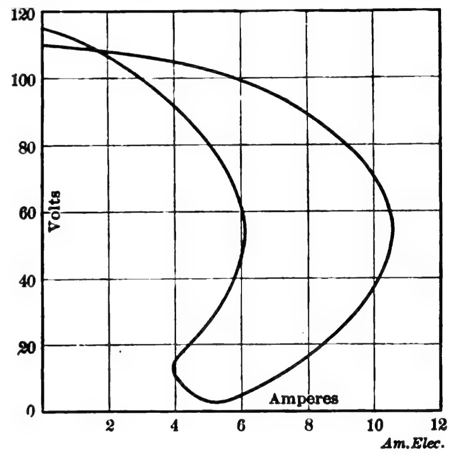


FIG. 5.—EXTERNAL SHUNT CURVE.

point was reached at a current output less than one-third the normal capacity of the dynamo indicates both a weak field and excessive armature reaction.

Transmission of Electrical Energy.

In a paper recently read by Houston and Kennelly before the American Philosophica Society, entitled "The Insulating Medium Surrounding a Conductor the Real Path of a Current," the subject is treated in a simple and highly interesting manner, no mathematics being employed. It is shown that the electric current travels from one end of a circuit to the other through the insulating medium surrounding the conductors, and is guided by the two conductors which, with their insulation, form the complete circuit. If it were not for these two conductors, any electric wave or impulse would radiate out into space in all directions, like light from an unprotected candle. The wire does for the electric wave what a reflector does for a search light; namely, localizes and concentrates the beam into a single path, whereby it may be transmitted to the desired point with the minimum attendant loss in transmission.

ELECTROLYSIS FROM ELECTRIC RAILWAY SERVICE.

BY PROF. ARTHUR J. ROWLAND.

The destruction of underground metallic structures, especially pipe lines and telephone cables by electrolysis, began when the first street railways using the overhead trolley and ground return were installed and put into operation. It was not until 1891 or 1892 that much trouble came to be found due to this cause, but since that time everyone interested in maintaining pipe lines and telephone cables intact in the streets, has been endeavoring to eliminate the trouble so far as may be possible. As long as present methods of distributing current to street cars are used, these difficulties will be found; and the study of the return circuit, not only with a view to eliminating electrolytic troubles when they exist, but also planning it so they never begin, is of the most serious importance.

All return current from the cars must pass to the station through the rails, or the ground, or the pipes and ground. No electrolysis takes place in the return circuit through the rails. All metallic conductors convey current through their mass, attended by no chemical action.

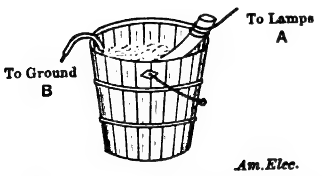


FIG. 1.—ILLUSTRATING ELECTROLYSIS.

The earth, that is, surface soil, is not a conductor; and no current will return through it unless it contains metallic salts which are soluble in water like carbonates, or organic salts and acids due to the decay of animal matter. Even then there is no conducting path through it unless the ground is wet, when these salts being dissolved in the water make one, and the current passing produces electrolysis of them. In the circuit including earth and pipes, similar actions to those last mentioned may be found.

The electrolysis takes place in solutions in the soil. A chemical dissociation takes place in them when current passes. That acid or alkaline part which is able to act chemically on metallic masses, moves in a direction opposite to that of the current to the place where the current came in, and there corrodes or rusts the iron, copper, or lead, as the case may be. The other part resulting from the chemical dissociation moves with the current to the conductor where the current leaves the soil, but does no harm, since it is not of such nature as to enter into chemical combination with it. The amount of this action at the place where the current enters is proportional to the current flowing and the time it flows. One ampere flowing for a year produces the same corrosive action as twelve amperes will in a month; that is, as many pounds of metal will be corroded. The amount of the eating away of the anode (conductor where the current enters the ground), differs too for different metals acted on. If some value of current acting for some length of time reduces the weight of iron in an iron anode by 1 lb., a lead anode would have lost 3.6 lbs. and a copper anode 1.1 lb., if located in the same circuit.

To sum up then, the amount of chemical action resulting in the destruction of the anode is determined solely by the amount of the current, how long it flows, and the kind of conductor from which the current enters the moist conducting earth. No matter what readings a voltmeter may give, and no matter what sort of further path the current takes afterward, these are the only things to be considered.

With the additional fact given, that to produce the losses in weight mentioned requires one ampere passing through the circuit for 4250 hours (if the electrolytic action were equally distributed over the surface of the pipe, for instance, and one knew the area from which current came) he could calculate the length of time which must elapse before the pipe would be corroded off. The main difficulty in the way of this is, however, the fact that the action is always irregular and the surface where electrolysis has made

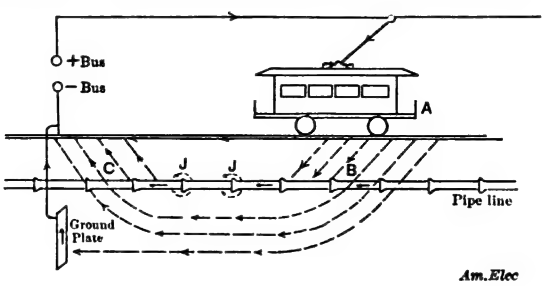


FIG. 2.—GROUND RETURN CIRCUIT.

trouble is an irregular one pitted deeply. This appearance can easily be studied by any one who has never seen it by producing some specimens of his own which are certainly corroded because of electrolytic action.

To do this, put at the bottom of a bucket, (Fig. 1) a piece of sheet metal which has a wire fastened to it, the wire leading over the edge of the bucket. Fill the bucket half full of ground and bury in the ground a piece of lead or iron pipe. Secure a wire to the pipe, preferably above the surface of the ground as in Fig. 1. Open the earth connection of a string of five lamps and insert the bucket and its connections, putting the end, *A*, to the lamps and *B*, to the ground if the trolley wire is the positive side of the circuit. Pour enough water into the bucket to wet the ground thoroughly and see that it is kept wet.

After several days an examination of the pipe will show the sort of results electrolysis in that sort of earth produces at the pipes. A little study of surface soil with respect to its conducting properties can be made at the same time. To one who has not experimented along these lines, some surprises are in store. I recently took some street dirt dug from a point close to pipes where I thought electrolysis might be taking place in a serious way, and found the resistance between a pipe and a metal plate 10 ins. square, the pipe and plate having a layer of about 3 ins. of earth thoroughly soaked with water between them, to be 450 ohms.

Since the electrolytic troubles are always found at the point where the current leaves a conductor for the ground, it is necessary to look for trouble from electrolysis only at such points as show a deflection up the scale on a voltmeter connected with its positive terminal to the pipes or ground and its negative terminal to track, since this means the pipes, etc., are anodes and so being gradually destroyed. If the reading is the other way the tracks suffer, but this is a matter of but small concern compared with the other.

Examine Fig. 2. If I connect my voltmeter from track to ground or from track to pipes or lead cables at *B*, the positive terminal must be to track to get a reading. All electrolytic corrosion takes place here on the track, bonds, and auxiliary conductor if there is any. At *C*, on the other hand, a reverse set of conditions is met and the voltmeter is put with its positive terminal to ground or pipes to get a reading. Here it is the pipes which are attacked. The three possible paths for current returning to the station are: 1°. Along track; 2°. Into pipes or lead-covered conductors at *B*, along the pipes to *C*, back into the track and so to the station; or 3°. Into ground at *B*, along through the ground and back to the negative bus, either through the ground plate or track.

The article by Dr. Bell on "The Earth as a Conductor," in the AMERICAN ELECTRICIAN for February, 1897, shows how almost no current will come through the grounded plate connection. This has been experimentally shown also by inserting ammeters into this circuit in plants having very large output. The great resistance in the ground is also evidenced by the fact that fires have been caused by gas and water pipes coming into contact with each other in buildings. These systems of piping are not widely separated in the ground, and so to maintain a difference of potential between them enough to strike an arc, the resistance in the ground has to be very high. A look through the reports of the Fire Underwriters will show that this is no uncommon cause of fires, and one that is hard to deal with because of the persistance of the difference of potential, due to which the arc causing the fire started. And so the time has gone by when an electrical engineer puts in ground plates to take care of the return current on any electric railway system, be it large or small, city or suburban.

We have left then two paths for the current, which must be considered, one through the pipes or lead-covered cables, and one through the track. In these two parallel circuits the current will divide in inverse proportion to the resistances of the two paths. If the path through the pipes has ten times the resistance of the path through the rails, one-tenth the return current follows the pipes. There are also divided circuits likely to be found along the pipe line if high resistances are at some of the joints, as at *J J*, in Fig. 2 Some of the current passes around the joint; through the ground outside the pipe or through the water inside, the rest through the joint, the division being according to the relative resistances of the paths, as just explained. Corrosion at the side of the joint at which the current leaves the pipe is sure.

In view of these facts and the relation of

the current flow to the fall of potential, a determination from voltmeter readings may be taken between track and pipes, showing those districts at which current leaves the pipes and where therefore trouble is likely to come sooner or later through their failure by corrosion. The area over which such readings are found, Mr. Farnham some years ago designated as the danger area—the area where trouble may come. As remarked before, the voltmeter readings taken within the danger area show a possibility of electrolysis, but do not make it sure that it is present. Since there is no way to know the presence of the electrolytic troubles except by seeing the pipes or proving the presence of current in them, the aim of the engineer is to reduce the danger area, or clear it away entirely; that is, fix things so there is everywhere a reading on the voltmeter only when the negative terminal is put to pipes or cables.

It might be well here to call attention to the fact that where telephone or other lead-covered cables are the ones in trouble, if this trouble is local the cable may be raised from its ground connection at the suspected point and an ammeter introduced from lead covering to earth. If a reading is obtained this will show that the trouble is electrolytic and how serious it is. If the ammeter does not show any reading, due to its inability to read very small currents, there may still be electrolytic trouble and this can be sought out by comparing the surface of the cable with one of similar sort put into the bucket mentioned before where electrolysis is produced. An ammeter put from track to water or gas pipes gives no reading of value at all, since this makes an auxiliary path for the return current of hundreds of times as good conductivity as the real and usual path, it may be, and so its readings become entirely misleading.

As to the voltmeter readings in the danger district. These are found to vary in value anywhere from zero to 25 volts, though usually 3 to 4 volts is not exceeded along a well planned road. The large readings may or may not indicate a large current flowing between the points where the reading is taken.

By Ohm's law, $CR = E$, and the voltmeter reading may be made large by a large value of either C or R. Generally it will be R, the resistance, which causes the big deflection.

Some days ago I made a reading of .4 volt between pipe and track, while the resistance of the connection was by measurement .23 of an ohm. The current there was at most .17 of an ampere. Occasionally there may be other causes for readings obtained on the voltmeter. At another place I made some readings from the negative bus bar of a station to the ground, getting results like this. I first used a Weston voltmeter with 500-volt scale ($R = 60{,}000$ ohms) and got a reading of 3 volts, positive end to ground, of course. The voltmeter was then changed for one reading 10-volts full scale ($R = 1000$ ohms) and the reading obtained was 1.2 volts. It was again changed for one reading 1 volt full scale ($R = 100$ ohms) and the reading dropped to .4 of a volt. This simply means that the difference of potential originally read was almost an electrostatic one and when the resistance at the voltmeter was dropped, it was nearly dissipated. The current flowing there was exceedingly small, much less than .00005 of an ampere.

While the above is true enough, one must not get the idea that voltmeter readings are not worth taking. If there is any electrolytic action at all, in course of time there will be serious trouble. A difference of potential positive to the pipes *may* indicate considerable current flowing out of them, and so serious and rapid action.

Many plans have been proposed for overcoming the troubles due to electrolysis and avoiding the dangers to pipe lines it produces, and some have been tried. One originally tried in Boston in the winter of 1892-93, and due to the suggestions of Mr. Pearson[1], then of the West End Railway, is as follows: The positive pole of the generator is put to trolley so that the danger district is brought near the station. Far from the station then, the current passes from track to pipe, but near the station from pipe to track again. Then large conductors are carried from the pipes at a point near the station to the negative bus bar directly. This makes the pipe negative to ground everywhere, and so no electrolysis takes place on it anywhere.

This method has been adopted in many places since, and is the best possible way to deal with trouble in lead pipes, or telephone or other lead-covered cables. It is not a good way to deal with trouble in gas and water mains if these are of cast pipe with lead-calked joints; it may do if the pipe lines in trouble are made with screwed joints and bolted flange couplings. The reasons are these: A lead-covered cable has a continuous conducting surface of about uniform conductivity and so no matter how much current is taken into the lead cover because of the reduction in resistance of the circuit at the station end by putting in the direct copper connection to the negative bus, no current passes out of the pipe anywhere into the ground. The resistance of the lead cover would be such that, I think, no case could arise in practice where enough current could pass through the cover to heat it. In case of pipes for water, steam or gas, the resistances at joints may cause the current to be diverted around the pipe joint through the earth outside or water inside or both, and so local electrolytic action be produced. In a pipe line with screwed joints the resistance of a joint is not likely to average more than an amount equal to 2 or 3 ins. of length of the same pipe. Flange couplings are usually of no greater resistance, though occasionally one will be found with a quite high resistance (equivalent to 300 or 400 ft. of pipe). With lead-calked joints the case is quite different. These resistance are very variable, no matter whether they are new or old. Such as I have measured vary like this:—.080, .033, .015, 1.625, 1.666, .0033, 1.70, .011 ohms, etc., in pipe having a resistance per foot of about .00025 ohm.

The danger of provoking electrolysis all along the joints of a lead-calked pipe by bonding from the pipe line to the negative bus bar at the station is evident. It seems to me it would be better to allow the electrolytic action to have its way close to the station, after all other precautions to avoid trouble have been taken, at a point where it could be directly dealt with, than to act all along a line of piping at every joint more or less.

It must be observed also, that bonding lead-covered cables to the negative bus from a point near the station, while it saves such cables from trouble throws more danger from electrolysis upon other pipe lines. For if the object desired is secured by making the lead cable negative to earth everywhere, other pipe lines are positive to it and so at every point where current leaves them for it, electrolytic corrosion takes place.

In suburban roads, especially if suburban is taken to mean a road all in the country with no lines of pipes following the road any great distance, then it will certainly be best to put the negative terminal of the generator to line, so scattering any electrolytic action (very small at most) far out toward the end of the line, and thus all piping connections about the station be saved from trouble. That this is a safe thing to do may be seen from a figure or two. A measurement from track to a line of pipes along a suburban road on a wet day and through ground thoroughly soaked with water gave a resistance of about 80 ohms. The maximum difference of potential acting between the same points due to return current was two volts; .025 of an ampere therefore was the maximum current flowing, perhaps for half a minute every eight minutes.

Other methods of avoiding electrolytic effects than the one mentioned, use devices at the station; and all make the potential on the pipes lower than that of the earth. This, as pointed out in the method spoken of at length, always makes more current follow the pipes than before. The more negative the pipes the more current is taken through them, and so the more trouble will be found throughout the lines of pipes at the joints, and on any isolated sections not so connected.

On a well constructed road where low resistance of the return circuit through the rails is found, there will be little trouble from electrolysis. The better the rail return circuit, the less is the electrolysis. A 90 lb. girder rail has a section of about 8.5 sq. ins. If the resistance of iron is taken at seven times that of copper, it will be found that the resistance is the same as that of a copper conductor of 1,550,000 circular mils section. This means resistance per mile per rail of .00368 ohm. A single track road has then in the rails a conductor having a resistance per mile of .00184 ohm and a double track road .00046 ohm per mile. The lowest resistance from track to ground I have found in a great city network is .090 ohm. This resistance is that into the pipes. In the circuit of which this resistance forms a part, next comes the resistance along the pipes, which, as we have seen, will run into many ohms in lines having lead-calked joints, and then the resistance back to tracks and to station through another .09 ohm.

In case there are large lead cables in this circuit and many of them and large pipe lines too, all in parallel, even a guess at the ground circuit resistance is impossible to make. But even counting the resistances as zero except into the pipes and out again

[1] Proc. of Amer. Inst. E. E., April, 1894. Farnham on Electrolytic Effects.

makes the resistances of the ground return through the pipes 100 times as great as through a mile of single track return for the great network spoken of. But the track is jointed and bonded and the bond resistance changes the condition of affairs, so that much more than $\frac{1}{100}$ of the total current may come back by way of the pipe line.

Freedom from electrolysis requires a good rail return, coupled with high resistance of ground return. For a low resistance of rail return, the main question to be considered is the bonding of the rails. When one thinks of a conductor of 1,550,000 circular mils pieced out with 500 ft. of No, 0 or No. 00 copper as bonds in each mile of length, it is plain that even the most modern bonds are nothing like as good as they should be. In laboratory tests I find that some late forms of copper bonds have resistances from .000042 ohm up to .00015 ohm per bond according to the make of bond.

The resistance of the bond is far more important than of contact with the rail. But even in the matter of contact resistance, since it has been shown[2] to depend on pressure rather than area of contact, the bonds having the widest area of contact may not have the lowest resistance at the contact. The shorter and thicker the bond, the lower the track resistance will be. Short bonds, however, are not likely to stay tight in the rails because of their inflexibility.[3] Bonds in use increase their resistance also as time goes on. It is not easy to get accurate measure of this increase and it is a variable one. My measurements on bonds in place in track, both new and old, indicate that a bond measuring .00012 ohm when put into the rails for a laboratory test, is likely to measure on the track ten times as much. Old bonds seem to have a resistance 20 per cent. or more higher than new.

To be sure of low resistance along the track then, not only must bonds be well chosen and well put in place, but must be given attention to see that they keep in good condition. To the same end the rails should be cross-connected at frequent intervals also, and near the station ground return cables should be put in to supplement the track conductor if large currents are carried. Mr. Hewitt, electrical engineer of the Union Traction Company, Philadelphia, has pointed out the propriety of insulating such return wire so that electrolytic action may not destroy it[4]. It may even be put on the poles or in a conduit with feeders, for electrolytic trouble in it will go on all the more if the pipes are well protected. For high ground resistance keep the track away as much as possible from pipe lines, and in the station make sure there are no ground plates or ground connections on pipes making a low resistance between them and the grounded bus bar.

Last of all, every pitting of pipes does not mean electrolysis. If there are impurities in the pipes or lead cable covers, these may in certain sorts of soil have a local action established like that on the zinc plate of a primary battery, which results in the using up of part of the material of the pipe to supply the electrical energy spent in the local current there set up. I remember being told of such trouble with the telephone cables in the city of Baltimore before they had any electric railways in operation there.

[2] Charles Wirt—*Electrical Engineer*, Aug. 5, 1896.—"Contact Resistance."

[3] Some figures on cast joints for rails in AMERICAN ELECTRICIAN, Sept. 1896, are interesting in this connection.

[4] Paper before Electrical Section of Franklin Institute, May 26, 1896.

THE EARTH AS A CONDUCTOR.

BY W. STUART-SMITH.

Dr. Louis Bell, in the February number of the AMERICAN ELECTRICIAN, under the caption "The Earth as a Conductor," points out the general worthlessness of the earth as a conductor for currents of any considerable magnitude, and also cites some experiments to show that remarkable decrease of resistance is occasionally found.

In the very exhaustive tests made by the writer to determine the distribution of stray railway current in the pipe mains of San Francisco, this great variation of earth resistance was noted and commented upon in published reports of the tests. It is believed that the facts then brought out deserve more attention than has been paid to them. It might be thought that the fact that there are places of low ground resistance is of little practical importance, but considered in relation to the electrolysis of gas and water mains, the matter becomes of the greatest importance.

The tests made in San Francisco were begun with the idea of locating and removing certain wire connections which, it was believed, had been made between the pipes and track with a view to utilizing the pipes as returns. These tests first consisted of potential readings between track and pipe systems and between the two pipe systems—water and gas; several wire connections were located by noting the sudden rise of potential between pipe systems when a point was approached where one system (it was always the water) was connected with the track. A decrease of potential between the connected system and the track at connected points served as a check.

It was thought such sudden variation of potential relation would be a sure indication of wire connection, and this was confirmed by the quick discovery and removal of three or four such connections. Then disappointments began to set in, and when it was certain a wired point had been located it frequently could not be found. Low earth resistance was not at first given credit for indications found, but it was thought the supplementary ground wire had made contact with sewer pipes somewhere in the immediate neighborhood.

Later, the fact was discovered that the resistance of pipe joints was so great that by making contacts on services or mains at distances of 25 ft. to 100 ft. apart, the direction of current flow in pipes could be determined, not only immediately alongside the track, but for blocks each side. This method of testing was subsequently employed in all cases, as well as the test for potential relation between systems, and it was soon found that every few hundred feet a point could be found toward or from which the current flowed in the pipe systems from all directions. Careful examination by unearthing the pipes showed no metallic path, and the idea was soon forced upon the writer's mind that there must frequently be found points where the earth resistance is very far below the normal.

Hundreds of tests were then made and it was found possible to map out along the line of the road, all places where there was an abnormal leakage of current between track and pipes. In the regions far removed from the power house, where the track is positive to the pipes, such points of low resistance do no special harm except as they cause a heavy leakage of current to the pipes, which must return to the track near the power house. In the region where the pipes become positive to the track, however, such low resistance points assume vast importance, since the larger portion of the current from the pipes to tracks returns over them, and at such points the greatest amount of corrosion will take place.

It was generally found that in the region surrounding the power house several points could be located toward which the current flowed from all directions, and, of course, such flow could only be caused by a good return path to the track at such point. In addition to such points of abnormally low resistance, there are, of course, many others in which the resistance is much higher than the points of lowest resistance, and yet is so much below the average that the greater part of the leakage current will return by local paths rather than be uniformly returned throughout a large region. The result of this is that slow corrosion is going on in spots distributed throughout the entire region where pipes are positive to track.

The companies may uncover pipes here and there, and, discovering no sign of corrosion, pat themselves on the back with the feeling that no damage is being done; and yet many badly corroded places may exist but short distances from where examination was made. This fancied security may go on for some years, when the discovery will suddenly be made that entire pipe systems, in regions surrounding power houses, must be relaid.

The danger from electrolysis does not come from the isolated cases where one or more sections of pipe are destroyad in a few weeks, because such places discover themselves at once; but it comes from those slower cases which require years to develop, yet which affect large regions. Failure of water supply at moments of greatest need may be the result of variable ground resistance, and hence such variable resistance becomes a matter of great concern.

The points of lowest resistance are not really the most dangerous, because, as shown by the writer, they can be readily discovered; but points of medium resistance are difficult to discover and yet cause local corrosion. The only remedy is to provide metallic paths of so much lower resistance that the current will be practically all shunted off from the earth circuits. An inconsiderable quantity of wire judiciously distributed will afford perfect protection from the dangers caused by variable earth resistance.

ELECTRIC PUMPING.

BY A. T. MALTBY, M.E.

The advantages of electric power for pumping purposes have been recognized for several years, but not until quite recently has it come into general use for this purpose. With the great improvements, however, in the last few years, in both pumps and motors, and in the development of speed and other regulating devices, the practical difficulties have been removed and electricity is now being applied to every kind of service where pumping is done.

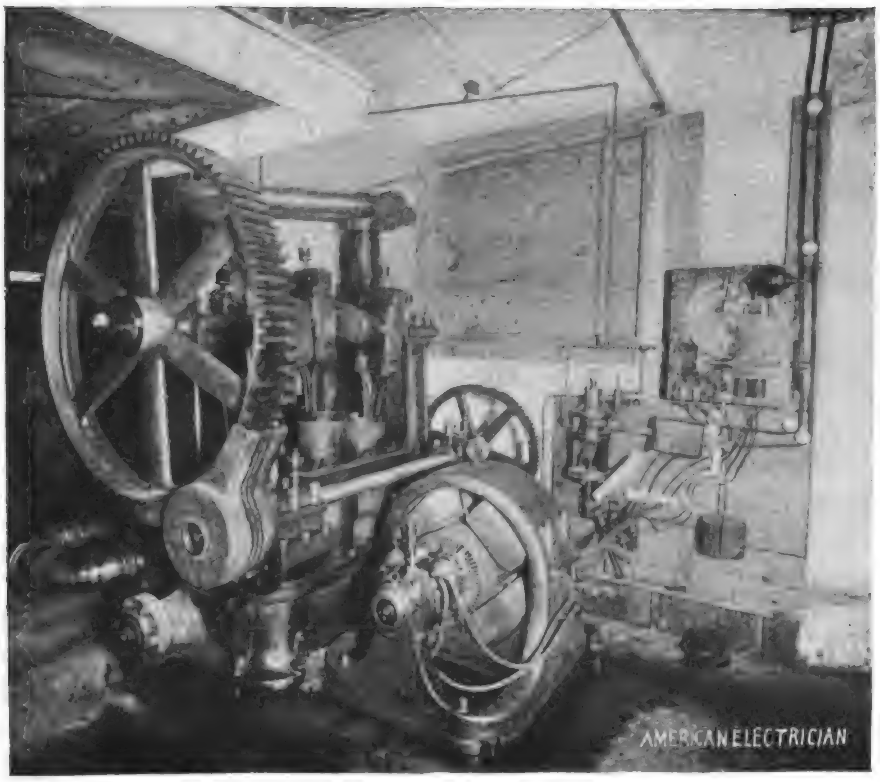


FIG. 1.—PUMPING PLANT IN METROPOLE BUILDING, CHICAGO.

Electric power as available for pumping may be considered under three heads, based on the nature of the generating power:

1°. Where electric current is generated by water power at a distance from where the pumps are located.

2°. Electric current generated by steam at a distance from where pumps are located.

3°. Electric current generated by steam at or near where pumps are located.

Class 1. The advantages under this class are saving of fuel, wages of firemen, handling fuel and ashes, boiler repairs, etc. As an offset to the above should be charged interest, insurance, taxes, etc., on the excess of cost of water power and electric plant over a steam plant for doing the same work. There are many instances where water power is owned by private corporations who have power to spare, where a contract to furnish electric power for pumping for factories or cities would be of mutual advantage. Many large plants under this head have been installed in the large mining plants in the West where the conditions were peculiarly favorable for electric pumping, and motors up to 240 HP each are in operation for this service. An illustration of the advantages of electric pumping under this class is furnished at Hudson, Wis., a city of about 10,000 inhabitants.

The city authorities early discovered that the expense of operating their water works with steam pumps was more than the income received from the sale of water. After several changes, a contract was made with Messrs. Burkhardt & Andrews who own a water power about 2 miles from the pumping station, and who have a franchise for lighting the city. This firm purchased its own pumping machinery, consisting of two 25-HP induction motors belted to two 8 in. × 10 in. single acting triplex pumps, each with a capacity of 250 gals. per minute, against a head of 250 ft. The contract has proved of mutual benefit, saving money for the city and utilizing the water power when not used for lighting purposes.

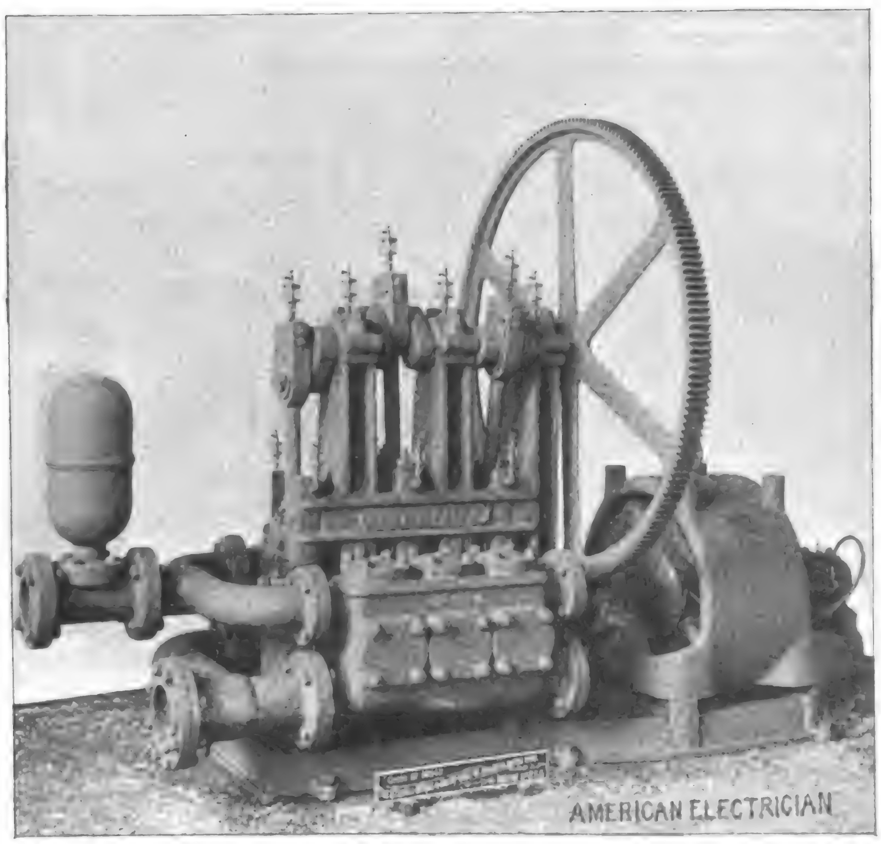


FIG. 2.—PUMPING PLANT AT CHIPPEWA FALLS, WIS.

Class 2.—The superior economy of a cut-off engine over the ordinary direct-acting steam pumps in general use for elevator and house service in large cities, and for general water supply in small cities, offers a wide field for electric pumping under this class. In the case of pumps for hydraulic elevator service and house pumping in large cities, the local electric plant can afford to supply electric power for this service much cheaper than a small independent plant can be operated, at the same time saving the annoyance of coal dust, grease, steam-pipes, heat, ashes, etc., and rendering the space occupied by boilers available for other uses. The operation of small municipal pumping plants has rarely been carried on with any degree of economy, because the pumps have been inefficient, and also because the cost of attendance is large in proportion to the amount of power developed. Under such conditions, there is no reason why electric lighting plants advantageously situated, should not contract to do public pumping as well as lighting. In most cases they could do the pumping at times when the load on the engine was light, thereby increasing its efficiency.

An illustration of this principle is furnished by the city of DeKalb, Ill. In 1893 the expense to the city for pumping during the year was 10.8 cents per 1000 gals. In 1895 a contract was made with the DeKalb

Electric Light Company to pump water for 4 cents per 1000 gals. A letter received from the DeKalb Electric Light Company, after the plant had been in operation one year, says that "The plant has given entire satisfaction to ourselves as a company running it, and to the city as the owner of the machinery. We are able to save the city quite a snug sum of money over the old way of running its water works and, at the same time, increase the profits of the electric station."

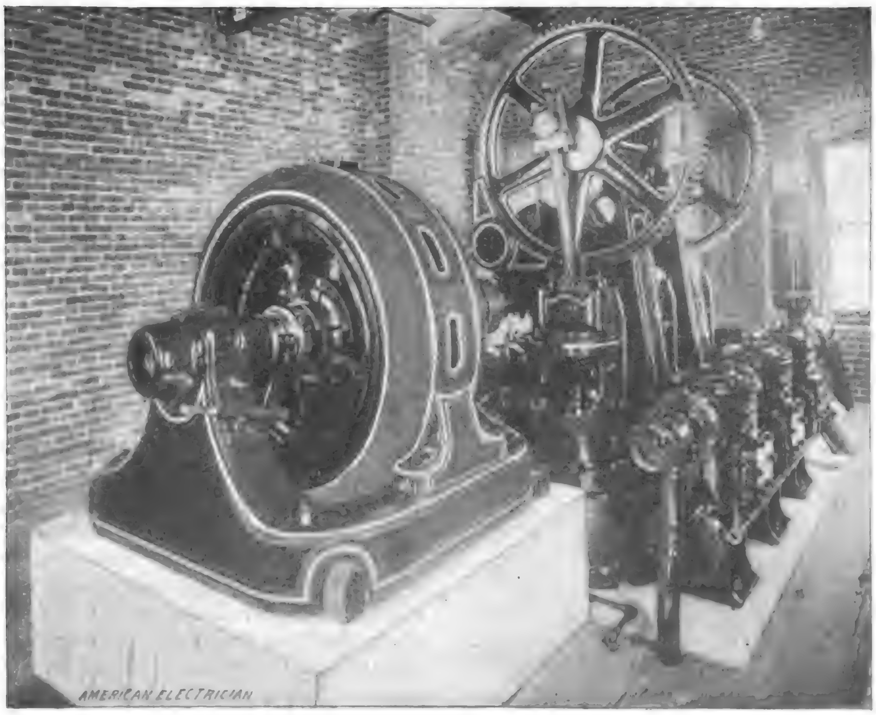


FIG. 3.—PUMPING PLANT AT ITASCA, MINN.

It does not always happen that the best water is to be obtained near the center of population, and frequently it is inadvisable to build a power house close to a pumping station, because of the cost of transporting fuel. In this case it is cheaper to transmit electric power on a wire, and an example of this kind is at Canandaigua, N. Y.

The village of Canandaigua owns both the pumping plant and the power house. The electricity is transmitted 3½ miles from the power station, conveniently located in the village, to the pump house on Canandaigua Lake. The three-phase system of transmission is used, and the current is furnished by a 100-KW generator. There are two 100-HP multipolar motors, direct-connected to two single-acting triplex pumps, having plungers 12 ins. in diameter by 12 ins. stroke, with a capacity of 1,000,000 gals. each, in twenty-four hours.

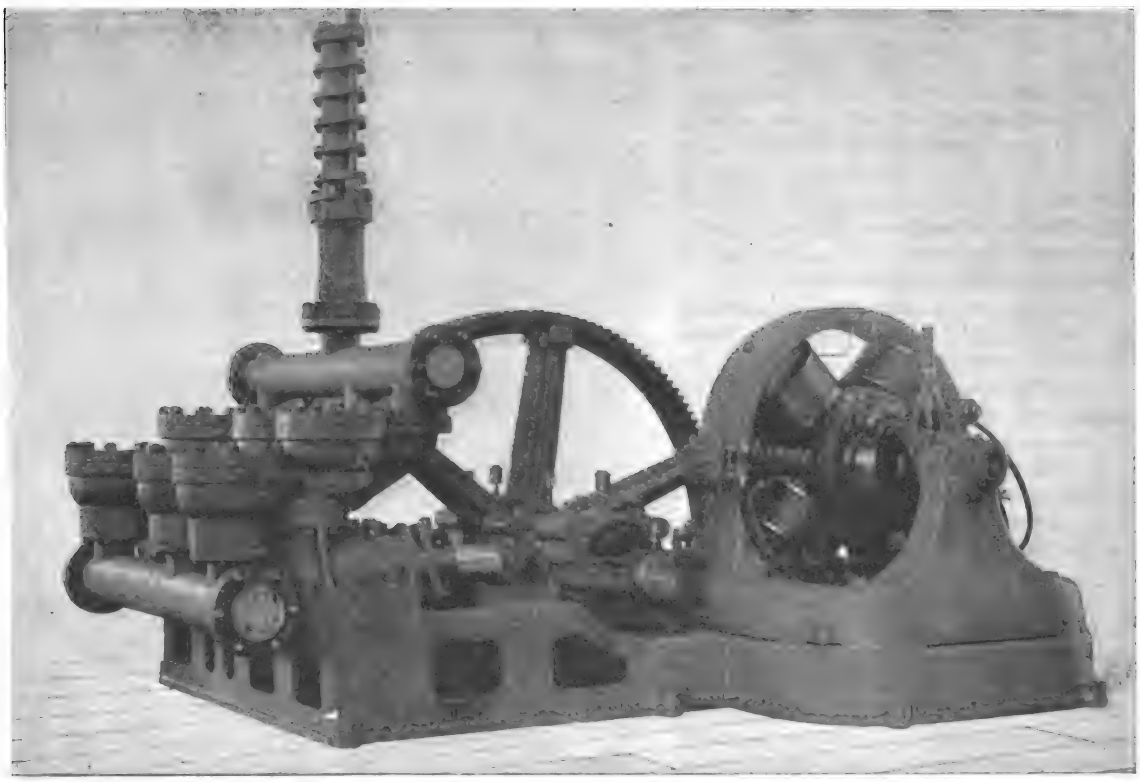


FIG. 4.—KNOWLES PUMPING PLANT AT CATORCE, MEXICO.

Another excellent adaptation of this principle is in a plant installed by the General Electric Company, at Itasca, Minn., a suburb of Duluth. The St. Paul, Minneapolis & Ohio Railway Company wished to provide fire protection for its docks and freight houses, which are located at Itasca, and after looking the ground over decided to make use of electric power.

The generator is located in the round house, where a battery of boilers is in constant use with steam available at any time. The pumping plant is located in a special building at the docks, 2½ miles distant from the round house, and is in charge of a watchman, who is on duty there all the time. The generator is an 8-pole, 75-KW, 2300-volt, three-phase machine, running 900 r. p. m. The full load voltage of the generator is applied to the line, and the motor is operated at 2080 volts, so that neither step-up nor step-down transformers are required. The distance of transmission or length of line from generator to pump or dock where the motor is located, is 2½ miles.

The motor is a 12-pole induction motor, running 600 r. p. m. and developing 75 HP; it is direct-connected to an 8 in. $\times$ 12 in. double acting triplex pump, the gears being so proportioned that the pump will run at a constant speed of 50 revolutions or 100 ft. plunger speed, with a capacity of 750 gals. per minute against 125 lbs. pressure. A relief valve, set at 125 lbs., is provided, which carries any surplus water not discharged by the hose nozzle back into the suction pipe of the pump. The motor is supplied with an armature provided with a centrifugal switch, by means of which the resistances in the armature are automatically thrown out as the motor comes up to speed. The freight house, which is nearly a mile in length, is wired and provided with switches at convenient points, so that by simply closing any one of these switches the motor can be started without the necessity of the attendant going to the pump house to do so. Convenient to each of these switches in the freight house is a hydrant and reel of hose.

Repeated tests have demonstrated that within fifteen seconds after a signal is given, the attendant can start the pump and have a stream of water playing upon a fire at any point within the building. As the work of the plant is intermittent, and a steam plant would require fuel and the constant service of engineers to keep steam up ready for an emergency, the advantages and economy of this system are apparent.

Class 3.—The advantages under this class are economy by reason of the higher effi-

ciency of electric motors and triplex pumps over direct-acting steam pumps, the ability to install the machinery in places that could not otherwise be utilized, the absence of steam pipes, etc.

An illustration of this principle is furnished

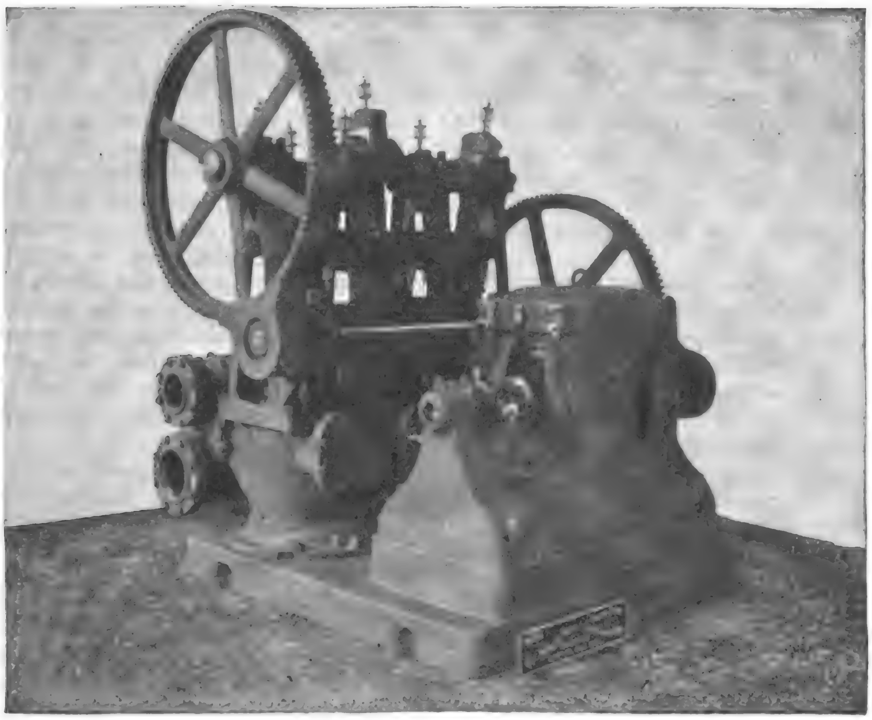


FIG. 5.—THRESHER MOTOR AND STILWELL-BIERCE & SMITH-VAILE PUMP.

by the plant installed by the Gould Company for hydraulic elevator service in the Metropole Building, Chicago. Electric current is supplied by high speed cut-off engines for lighting and power purposes. The direct-current system is used at 110 volts, the current being distributed to different parts of the building for lighting purposes, operating laundry machinery, ventilators, pumping, etc.

The elevator pumping plant works on what is known as the pressure-tank system, and consists of a 17½ HP, moderate speed motor, direct connected to a triplex pump having 8 in. plungers with 8 in. stroke, and of a capacity of 200 gals. per minute against 125 lbs. pressure. The pump is fitted with a Mason by-pass valve and there is also placed in the electric circuit a snap switch operated by a Mason regulator, and a specially constructed automatic starting rheostat made by the Cutler-Hammer Company.

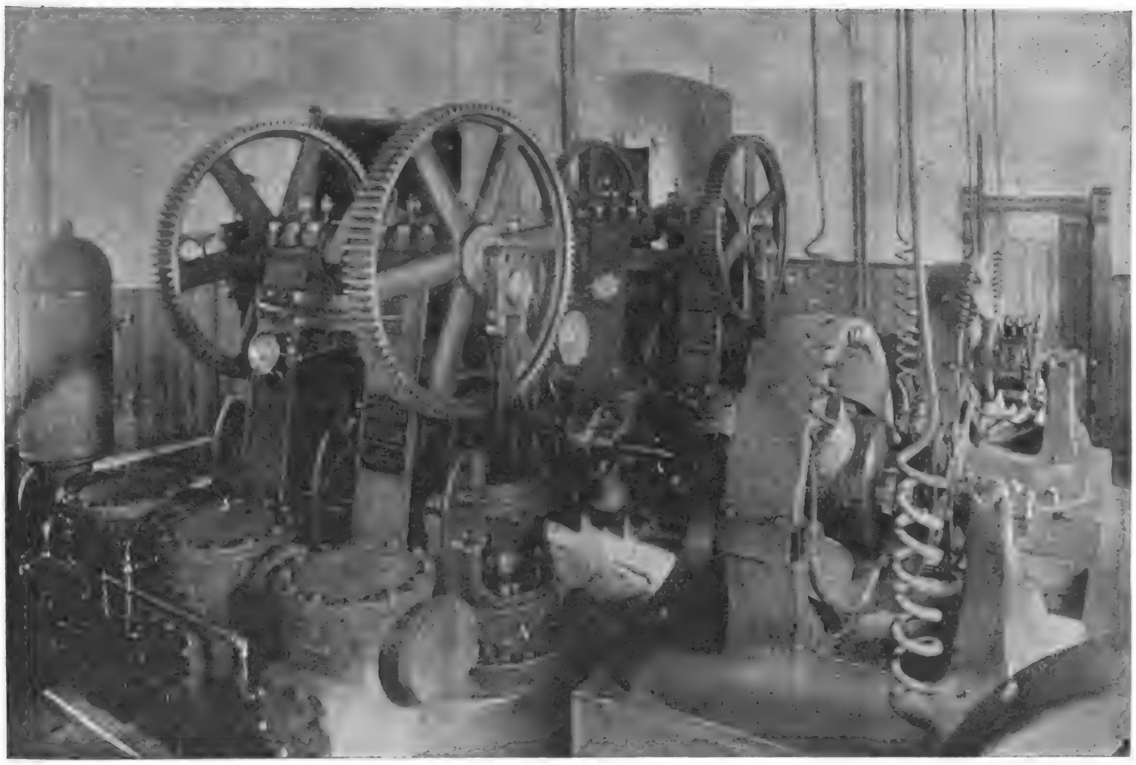


FIG. 6.—GENERAL ELECTRIC MOTOR AND GOULD PUMP AT DE KALB, ILL.

In practical operation the plant runs continuously during the busy hours of the day, the discharge of the pump passing through the by-pass valve into the suction pipe where the pressure in the pressure tank raises to 110 lbs., the valve automatically closing when the pressure drops below that point. At other times the plant runs intermittently, the Mason regulator pulling the switch open and thereby breaking the circuit when the pressure reaches 110 lbs., and closing the circuit again when the pressure falls below that point. The rheostat is provided with a small auxiliary motor which operates the arm of the rheostat, cutting out the resistance in the box and automatically starting the pump where the circuit is closed.

One of the latest improved plants of this class has been installed by the Stilwell-Bierce & Smith-Vaile Company, of Dayton, O., in the State Home for the Feeble Minded at Chippewa Falls, Wis. The special features of this plant are the speed regulation of the motor and high speed of the pump.

Electric power furnished by the main plant located in the building is supplied to a 16-HP motor manufactured by the Gibbs Electric Company, Milwaukee, Wis., direct-connected to a Smith-Vaile 5 in.×6 in. double acting triplex pump designed to run at a speed of 100 revs. with a capacity of 300 gals. per minute against 75 lbs. pressure.

The direct current system is used at 220 volts. The motor is a specially constructed machine with a shunt winding, and has a very large range of speed regulations by simply regulating the amount of current in the fields. The motor therefore runs at approximately the same efficiency at all speeds, and its efficiency is the highest possible.

The advantages of this method of control are that, first, the efficiency of the machine is not sacrificed; second, that the regulating box is simple and easily manipulated, as it handles only the small current which passes through the fields, and not through the main circuit. The motor at its maximum speed runs at 1000 r. p. m. and by cutting out resistance in the regulating box connected with the field coils, the speed is reduced to 600 r. p. m. without affecting the efficiency. It is geared to the pump at a ratio of 10 to 1, so that at maximum speed the pump runs 100 r. p. m. and can be set to run at any intermediate speed down to 60 r. p. m. The advantage of this speed regulation without loss of efficiency is of the highest importance, and marks a distinct advance in the application of electric power.

Triplex pumps, while recognized as the best type of power pump under any condition, are peculiarly adapted to electric pumping, as their hydraulic action is synchronous, offering an even, constant and un-

varying resistance to the motor, thereby lessening the tendency to heating and sparking of the motor, at the same time consuming less power for the same amount of work than any other type of pump.

ALTERNATING CURRENT WORKING.

BY H. E. RAYMOND.

In a previous article on this subject, the various ways of arranging simple power transmission generating stations were discussed, and, for the most satisfactory service, the use of individual driving machines for each generator was recommended. Several ways of connecting transformers for use in synchronizing and paralleling alternators were also discussed, and preference given to such as would allow of the primary or main wires being kept entirely separate, until the generators were in phase. In referring to the action on the line of two generators, connected by one ring each, when in phase opposition, it was stated that the effect on the line of two armatures of 500 volts each in series caused a spark to jump one-half an inch. A typographical error caused this rather incredible statement, the armatures being 2500 volts each.

In operating multiphase generators, great care is necessary on the part of attendants, in determining the needs of the "other end" of the system, and in so conducting the generating station as to meet all the requirements of the consuming portions. The ordinary conditions of operation are often greatly altered by some extraneous disturbance, or whim of nature, and, in probably the majority of cases, the disturbance is most keenly felt at that portion of the plant furthest from the source of supply; that is, furthest in proportion to the amount of power consumed.

It is generally the case, that the attendant at the motor plant of a system can, not only tell what is going on at his own machines and on his switchboard, but can also tell what is occurring at the generator; and, if his station is the principal or total consumer of the power transmitted, his instructions or signals should be obeyed to the letter.

We would beg to say to the reader here, that these articles are not the expressions of theories, but that they are expressions of what the observation of the writer has induced him to judge to be some of the mistakes and causes of success of power transmission in isolated plants. In central stations there is always the direction of a manager or a superintendent, to regulate all matters relating to the plant and to the help, and certainly in most cases such a man has both the welfare of his company and the satisfaction of its customers continually in mind. On the other hand, it seems unfortunately to be true that a great many isolated plants, power transmission plants and other "side shows" to some greater system, have no directing mind directly in charge of all their ramifications; or, if there is such an one, he seems to be handicapped from start to finish by interferences of those, whose position places them in authority over him, but whose training better fits them for anything other than the supervision of electrical machinery and distributions. Under such conditions as these, we find that there is often, instead of a good-natured rivalry, for the good of all, between the different sections of a system, a petty jealousy and resentment of anything that can be interpreted to mean presumption on the part of anyone connected with the plant in a subordinate position, such as a switch-board attendant at a sub-station.

In systems of power transmission where there are generally two or more distinct stations, the strained relations between the men at the generating and those at the consuming terminals of the plant, ought in most cases to be promptly stretched until they break and a new arrrangement speedily made.

This rather long statement regarding men rather than things, may seem to be a digression from the subject in hand, but as so many owners suffer as much loss and undergo the imposition of as much poor service from this cause as from, perhaps, all others combined, it seems to be only just for those who have the opportunity, to do what they can to obliterate this evil. A man who will allow his personal jealousies to interfere with his employer's best interest, is certainly not fit to work within gunshot of an electrical plant.

There is little to be gained in respect to the service rendered, in trying to keep one portion of a power transmission up to a high standard if the others are not also so kept; while there is everything to be gained by keeping it in total in as good condition as possible, and in sustaining all the parts in harmonious accord. Let us state a simple case as an example.

A generating station has for one unit a polyphase generator with its own individual exciter. This generator supplies the current used by a motor employed in driving a very unsteady and fluctuating load. The control of the load is partly in the hands of the motor tender; that is, he can prevent too great a load, by throwing a circuit breaker on a railway set driven by the motor. The voltage of the polyphase system is regulated by hand, and there is a system of signaling, by means of which the motor attendant may call the attention of the dynamo tender to the fact that the voltage at the motor is higher than necessary, or too low to carry the load.

A comparatively heavy load comes on the railway machines, the increased current causes a larger drop in the transmission lines, and the armature reaction reduces the voltage of the generator. The voltage not being raised, the motor tender signals for more, and if it still remains low, the circuit breaker must come out, or the motor will fall out of phase and stop. Perhaps the generator tender is in a bad humor, perhaps the signal startled him, and he resents it. He neglects to raise the voltage as he should. The motor tender throws out the circuit-breaker several times, and thus delays the cars, the generator tender getting more irritated every time. The cars are now late and when the power is again given them, the motormen try it—they find it stays a little while—and then make an effort to gain the time lost. This causes a load still greater, and more than the generator man was figuring upon, and the motor is out of step and down before they can catch it. A very slight raise in the impressed voltage at first would have prevented all this, and stopping during working hours costs money.

This no doubt sounds childish, inexcusable and unlikely, but it is only one of many such instances that have come to the writer's personal notice.

One naturally asks "Why are such things tolerated? Why is the man kept?" Because a man who will treat his employers that way has necessarily many explanations on hand at all times; for it is obvious that a simple statement of real facts would not be accepted as an excuse in such instances; and when his superintendent (mind you, the electrical plant is a side show), who, in matter of technical knowledge is often a layman, asks for the cause of the shutdown he gives such an involved statement of technical terms and impossibilities, that the man is digusted with electricity in its sum total, and yet glad that he has a man who so thoroughly understands his business (?).

If the distribution, of the power generated, extends over a large area, and includes a number of substations, it is, no doubt, advisable to use pressure wires from the center of each district to the central station. It is also certainly true that even if the plant has but one consuming station pressure leads would be very useful, and if there were no other means of communication, necessary.

In the latter case, a most useful plan is found in the employment of a system of signaling. This should be as simple as possible, and may generally very easily be devised to be used in connection with pressure wires.

A description of the simple signaling system we employ may be of use to some. The pole line consists of two sets of wires, on two cross arms, carrying alternating three-phase currents at 2800 volts. The upper arm carries three wires and the lower arm four, one being a spare wire.

Beneath these, on brackets, is strung a two-wire concentric cable, used for telephones. This being heavily insulated externally, and of only No. 16 B. & S. copper, was too large to support its own weight, and was suspended by clamps from a No. 8 galvanized-iron wire. At first it was intended to simply use telephones with this cable, and not only talk through them, but also to give signals by means of their magneto bells. The faint tones of the bells and the time required, in signaling, to turn the crank, made this plan unsatisfactory, and other means that were more reliable were decided necessary.

Considerable difficulty was experienced in obtaining satisfactory telephones, the Blake type of transmitter refusing to remain adjusted for more than a few minutes at a time. Rather peculiar actions were observed in experimenting with this style of transmitter. Sometimes it would work quite well, the enunciation of the speaker being distinct and loud, but in a few minutes it would be impossible to distinguish a word. Sometimes one end could hear and sometimes the other end. Most experts laid this to some induced action of the power lines on the cable. I must confess that I cannot see how this could be true in the case of a concentric cable, though perhaps it was. One

thing troubled us; the telephones acted as well and as badly when there was no current passing on the lines, as when they were loaded. The Blake's were soon thrown out and carbon telephones installed, these giving excellent service regardless of the current passing overhead.

In respect to the signaling between stations, the requirements were particular, though very simple. The generating station contained two belt-driven generators and nothing else; so all that was necessary here was a bell that could be heard above the noise of the two belts. At the motor station the noise was so great that a 6-in. vibrating bell was not audible 20 ft. away, this being due to the fact that the motors were situated in a room containing very noisy machinery. We wished to avoid the trouble and uncertainty of batteries and also use large bells, so we installed two single-stroke gongs, one 8 ins. and one 12 ins., actuated by means of a direct current at 275 volts to each bell. These were placed in series on a 550-volt electric railway circuit.

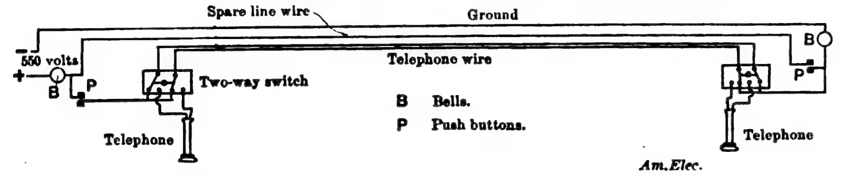


DIAGRAM OF BELL AND TELEPHONE CONNECTIONS.

The connections of these bells and telephone are shown in the accompanying diagram. There being a spare line wire, the telephone cable is used merely as one wire, thus avoiding the strain on insulation, which would have have resulted if both circuits were in the cable.

These bells we find very useful, and in an emergency the celerity with which signals can be given is of obviously great value.

MICROPHONIC TELEPHONIC ACTION.

BY PROF. R. A. FESSENDEN.

The electrician who finds himself opposed, in a question concerning the theory of the telephone, to so eminent an authority as Dr. Berliner, has but little cause to congratulate himself. If, therefore, after reading the letter published in your March number, I still find myself obliged by the facts with which I am acquainted to hold to my original opinion, it will be understood that I differ from Dr. Berliner with great reluctance.

Dr. Berliner's theory, as outlined, is that the change of resistance with pressure is due "to the variation in the thickness of the layer of air or gas between the two electrodes in so-called contact."

The question then arises, "Is it meant that the thin film of air is to be considered as conducting in the sense in which we ordinarily use that word?" Evidently not. For the ohmic resistance of air is very high, is indeed probably, from theoretical considerations, when pure, infinite. But we can fix a lower limit. I have had two plates, each of more than 100 sq. cms. cross-section and less than 1 mm. apart, so well insulated by air and silk suspensions that less than unit deflection was obtained with a difference of potential between them of 100 volts on a galvanometer capable of reading 10.10 amperes. The resistivity of air must then be greater than 10.15 ohms.

Let us take, then, two carbon buttons which have an area in so called contact of 1 sq. mm. Suppose that they are brought together so that there is only room between them for a layer of air, one single atom thick. Then the resistance of that layer of air must be at least, since the diameter of the atom is more than 10.8 cms., at least 1,000,000,000 ohms. Consequently, if microphonic action were due to conductivity through a thin layer of air, then, in the most favorable condition imaginable, when we had two pieces of carbon in contact of 1 sq. mm. cross section, we would need at least a pressure of 1,000,000 volts to drive a current of $\frac{1}{1000}$ ampere across the contact.

More probably it is meant that on the surface of the carbon the air or gas collects in a thin layer, which has different properties from air in its normal condition. This we may admit as extremely probable, if not certain. For this layer shows itself in a great variety of phenomena. The surfaces of almost all bodies seem to have the property of condensing air on them. For instance, we have the old experiment of wiping a copper plate very carefully, placing a coin on it, leaving it for several days, and then taking it off and breathing on it, when an image of the coin will be seen.

More decisive is the little-known experiment of Magnus (Pogg. Annal. 89,604) who by measuring the expansion of gases contained in vessels of the same capacity, but of different areas of surface, was able to determine the exact amount of gas occluded upon the surface of the glass. In one case the amount condensed on the walls of the glass was found to be equivalent to a layer .0008 CM thick.

Another well-known phenomenon is the occlusion of air on the walls of a vacuum pump, which proved to be so serious a matter that I believe the Sawyer-Man Company many years ago, used to coat the entire interior of the pump with a thin coat of paraffine, to prevent the film of air sticking to the sides as the mercury rose in the pump (a method since used also in the preparation of the mercury standard ohm). The necessity for freshly polishing glass before coating it with collodion for photographic purposes, the singing sands and many other phenomena all point to the actuality of this condensation layer.

The thickness of this layer is very small. In the case quoted above, from Magnus, we may find by calculation that the maximum number of molecules condensed would form a layer less than ten atoms thick. In the case of charcoal we find that if we consider the charcoal as perfectly porous, we have the thickness of the layer on the average less than $\frac{1}{1000}$ of the thickness of a single atom, if the gas be air. This small figure is, however, due to the fact that the charcoal is not perfectly porous, so that we will probably not be wrong in assuming the layer of air on the surface of a telephone transmitter to be several molecules thick.

This layer, on account of its density and the fact that it does not immediately expand on the pressure being released, is either a fluid or a solid, and is, from the fact that we get carbonic acid gas on slightly heating the carbon, probably in a state of loose chemical combination. In this condition it is perfectly conceivable that it can conduct. Not what we call electrolytically, however, for with perfectly dry carbon electrodes we do not get sufficient polarization.

This latter fact also disposes of the arcing theory, for the conduction in the arc (as we see from the fact that in dilute oxygen, carbon is plated over to the negative pole, sometimes to the depth of an inch, or more, while in hydrogen it is plated over to the positive, in the form of lamp black, and also from a number of other phenomena, connected with the distribution of the spectrum, and the places occupied by the positive and negative constituents in the arc is electrolytic. If the arcing theory were true we would have a different resistance from the metal plate to a carbon one, while my experiments show that there is no great difference.

The objection has sometimes been made to the arcing theory that there is a counter voltage in the arc. This, however, is not correct, as I shall show in a paper shortly to be published, but is a true resistance capable of being removed; so that I have recently been running arcs from one cell of storage battery. A true polarization effect, however, but quite small, exists and as it cannot be got rid of, this is a fatal objection, which seems also to have been partly adopted by Heaviside. (Papers, Vol. 1, p. 181.) The conductors must therefore be of the same nature as that which takes place in metals. So far Dr. Berliner's theory, if I have correctly interpreted it, is consistent. When, however, we go on to examine the law of variation with distance, we arrive at a fact which I cannot help regarding as fatal to the theory. This is the shape of the curve connecting resistance and displacement.

Let us take two irregularly shaped conductors, immerse them in a conducting fluid and approach them. Then it is easily shown mathematically, or by experiment, that the form of the curve connecting resistance and displacement must be of the form, *A* (Fig. 1), or at the limit, when the surfaces are perfectly smooth and very large in comparison with their distances, of the shape, *B*. This is for the reason that the lines of flow through a conductor tend to spread out, so that, in the case of two carbon rods in a large vessel of acidulated water, the resistance between the rods depends upon their size, and is hardly affected at all by their distance apart.

Now, as a matter of experiment, the relation is of the form, *C*. This I have found from many experiments. In no case have I ever got a curve like *A* or *B*.

Now the only thing which will give a curve like *C*, of which I am aware, is a pressure of a conductor on another conductor, thus giving, as the pressure is increased,

so as to halve the distance, approximately four times the area of contact, and therefore, one-fourth the area of contact resistance.

We are, therefore, driven to the conclusion that the resistance of a carbon contact is due to direct contact, and that when pressure is put on, the prominences on the carbon are flattened, as shown in the lower part of Fig. 2, and that it is this increase of area with pressure that gives the decrease of resistance.

This conclusion is fortified by the fact that if we take two bicycle balls, wipe the film of air from them, immerse them in olaine oil, and apply pressure, we get a curve exactly of the same general nature as that obtained from carbon; and, moreover, that curve is in agreement with what we can calculate from our knowledge of the elastic modulus of steel.

We meet another difficulty in the gaseous film theory. "How does the film keep the carbons apart under such large pressures?" For if we increase the pressure gradually from zero up to the crushing point of the carbon, there is no evidence of any change in the nature of the resistance. Remembering that there is no surface tension between the gas and the carbon, and no surface tension between the two layers of condensed gas, we see that the only effect which could resist approach would be the additional surface made when the film was squeezed out at the sides, between two proximate carbon particles. This calculation at once proves to be entirely inadequate.

The film of condensed gas must, therefore, possess elastic properties not due to surface tension, *i.e.*, it must be of the nature of a solid. This brings us back again to the contact theory, the only difference being that now we have contact between two pieces of solid matter, formed by a combination of the gas and the carbon, while before we had only the carbon. This last supposition is, however, quite unnecessary, as we

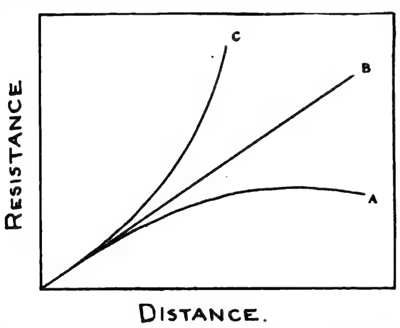


FIG. 1.—FORMS OF CURVES CONNECTING RESISTANCE AND DISPLACEMENT.

have seen that bicycle balls give similar effects in a case where there does not seem to be much chance for the film of gas to exist.

To take now Dr. Berliner's arguments, I do not see that the effects he describes disagree with the contact theory. Taking the question of resistance, I know of no reason why we should not expect to get resistances of 1,000,000 ohms, or even 100,000,000 at a microphone contact. This value agrees quite well with what we should expect from the known resistance of carbon, and from the contact theory, on the assumption that we have the contacts very fine points. And this is on the supposition that the carbon is pure. If we consider high resistance carbon, *i, e.*, higher resistance than arc light carbons, such as are commonly used in microphones, we might expect to get continuous resistances of several hundred times the above amounts, on account of the impurities reduced or oxidized at the point of contact.

The reduction of resistance in vacuo does not seem to be conclusive either. By immersing the contact in a conducting substance, such as air at comparatively low pressures is, we are simply putting a resistance is parallel with the microphonic contact, and we should consequently expect the resistance to be reduced, just as it would be if we put the contact in acidulated water or mercury. Again, in vacuo the impurities in the carbon may be reduced to a metallic

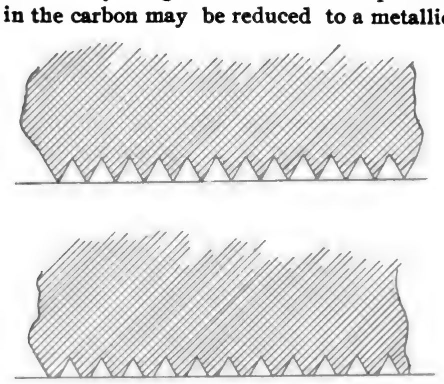


FIG. 2.—FLATTENING OF CARBON PROMINENCES BY PRESSURE.

state instead of being oxidized, when contact is varied.

Again, the effect of gold plating an electrode is only what might be expected. The gold is of high conductivity in respect to the carbon; as all the resistance is at the contact, it should do away with practically all the resistance at the contact, and so spoil the action almost entirely. This seems to me to be a strong argument against the gas film theory, for if the film is a conductor, then why is not the gold plated on the outside of the film? And if so, the film being still there, why does the microphonic action go on? Its stoppage is conceivable on the contact theory, but not on the film hypothesis.

As regards the use of metals as microphones, I would say that in my experience it is quite possible to get microphonic results from metals, but that it is quite impossible to get good speech. This, I think, is accounted for by the fact that by plotting the pressure resistance curve of carbon, we got a hysteresis loop, which is fairly small but quite regular. In the case of the metals, however, there is great difficulty in getting the same cycle twice, even when all slipping is done away with, though this irregularity is done away with to a considerable extent when the metals are immersed in oil.

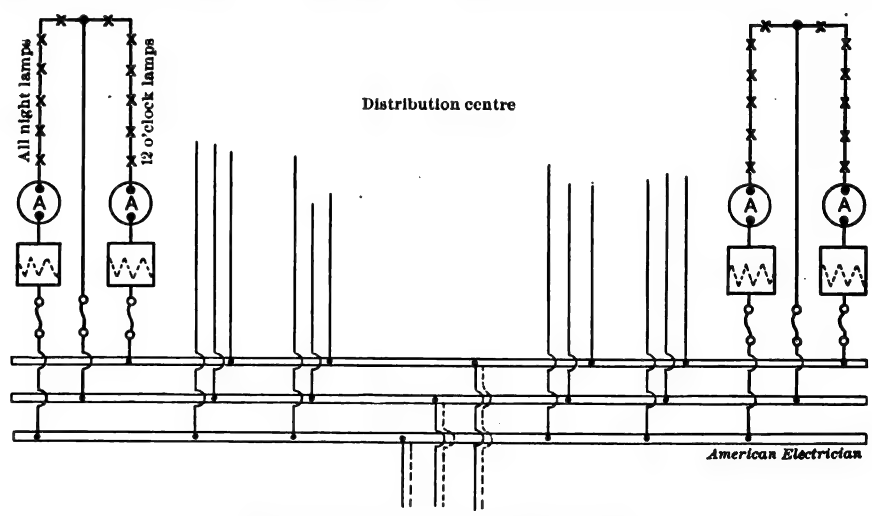
To resume: The facts observed by Dr. Berliner agree quite as well with the contact theory as with the gas film theory. There are very considerable difficulties in accounting for the mechanical strength which the gas film must have if it is to support the pressures used in practice.

The law of variation of resistance is inconsistent with any theory proposed, except that of the variation of direct contact.

ARC LIGHTING IN EUROPE.

In an interesting paper read by Mr. C. Wiler at the April meeting of the Chicago Electrical Association, a description is given of the arc lighting portion of the combined railway and arc lighting plant of the city of Munich, Bavaria.

The voltage of the arc generators is 540, and twelve lamps are connected in series in one circuit. The feeders are run to well designed distribution centers, which are located on the street and resemble patrol boxes in their exterior appearance. From here the arc circuits branch out. The all-night circuits are connected with the same side of the bus bars in the distribution center as the incoming feeder, while the twelve o'clock circuits are connected with the other side. Both sides can be disconnected by an automatic cut-out, the fine wire winding of which is connected with a test wire, which indicates in the station the voltage of the feeder end. By short-circuiting the voltmeter in the station, the current rises sufficiently to operate the automatic cut-out, which disconnects the desired circuits.



THREE-WIRE ARC LIGHTING CIRCUITS.

In the old part of the plant (see illustration) the three-wire system is used for the feeders, as well as for the arc circuits. The all-night lamps are placed on one side of the neutral, the midnight lights on the other. The three-wire system is changed into a two-

wire system after midnight, and the disconnected dynamo can be used for the charging of a storage battery during the rest of the night.

A table accompanying the report gives some data relating to various public arc plants, from which it appears that in no European city are clear glass arc globes used, that practice being peculiar to the United States. Lamps in European cities are usually placed from 130 to 230 ft. apart. In Paris the distances are 165 to 230 ft., in Berlin 134 to 197 ft., in Cologne 150 to 200 ft. and in Milan 130 to 195 ft. The height at which the lamps are hung varies from 14 5 to 34 ft.; in Paris the height is from 14.5 to 19.5 ft., in Berlin 26 ft., in Cologne 23 ft., and in Milan 30 ft. The largest number of street arc lamps in Europe are in Munich, numbering 780, and Paris and Berlin have 313 and 320, respectively. In the United States arc lighting is much more extensive, the numbers for New York and Chicago being 2621 and 1486.

NOTES.

The Telephone.—The latest addition to the field of technical journalism is the *Telephone*, a monthly published in Chicago, of which the first number is dated March. While in some respects apparently a "house organ," and frankly a bitter opponent of the American Bell and its licensees, its pages contain much matter of general telephonic interest. The pages of the first two numbers give evidences of ability on the part of the editorial staff, while typographically and in arrangement of matter, the usual ear marks of the editorial novice are almost entirely lacking.

Marine Engineering.—For many years it has been a reproach that the United States possessed no organ representative of marine engineering at all comparable with any one of a number of foreign publications, partly or wholly devoted to that branch. We are pleased to note the appearance of a monthly, under the name of *Marine Engineering*, whose object is to fill the want felt for a publication designed to be "accurate, absolutely impartial and altogether devoted to American shipbuilding and engineering," and whose scope will be sufficiently broad to invite the support of the professional man and manufacturer as well as of the practical engineer. The first number (April) contains the initial article of a series by Prof. R. H. Thurston on "High Steam Pressures on Seagoing Ships and in General," which promises to be a valuable contribution on steam working from the latest standpoint.

Self-Inductance of Coils.—In a paper by Prof. A. C. Crehore, printed in the *London, Edinburgh and Dublin Philosophical Magazine* for March, some numerical data on the inductance of a given coil are included. The coil is wound on a spool 18 ins. long and 1 in. in diameter, the hole in the spool being about ⅛ in. less in diameter. The wire is No. 22 B. & S., single cotton-covered, wound in 8 layers of 492 turns per layer, making a total of 3936 turns. The core consists of No. 16 soft iron wire of the same length of the spool. The resistance of the coil is 16.2 ohms. With no wire in the spool, the self-inductance of each coil was found to be .0166 henrys; with the iron core in place, it became 1.084 henrys, or 65 times greater. With one ampere of continuous current, such a coil would give a drop of 16.2 volts. With the same value of alternating current having a frequency of 125 (15,000 alternations per minute), the drop would be 20 volts without the core, and 85 volts with the core.

Rapid Telegraphy.—Prof. A. C. Crehore and Lieut. G. O. Squier, U. S. A., in a paper read before the April meeting of the American Institute, entitled "The Synchronograph: A New Method of Rapidly Transmitting Intelligence by the Alternating Current," describe a new method of rapid telegraphy. The transmitter consists of a mechanism for opening an alternating circuit at the exact instant when zero value is reached, and keeping it opened during one or more alternation; one or more half waves may thus be omitted according to the requirements of the telegraphic alphabet. By means of a perforated paper band corresponding to the message to be sent, the half waves are omitted in the proper order. The receiver rests on the principle that if a ray of polarized light is passed through liquid carbon bisulphide or one of a number of other substances, the plane of polarization is rotated by any change in value of a magnetic field set up by a coil surrounding the liquid—that is, by any change of current in the coil. This principle is utilized to register the current from the transmitter, by photographic means, the suppression of the half waves above referred to being thus registered at the receiving end of the line in the form of a record comparable to that printed on a tape by a Morse receiver. The transmitter may also be used in connection with a chemical receiver, such as the Delany. In experiments no difficulty was experienced in obtaining records with the use of a frequency of 545 periods per second, which corresponds to a transmission of between three and four thousand words per minute.

Annual Report of the General Electric Company.—The annual report of the General Electric Company, dated Apr. 27, shows that during 1896 the earnings amounted to almost $13,000,000 ($12,820,395.87). Deducting expenses, a balance of $1,613,007.22 remained. The following amounts were written off during the year: For sundry losses and allowance for possible losses, $318,531.13; patents, $349,919.20; inventories and consignments, $61,084.36. During the year one large factory of brick and steel construction was added to the Schenectady plant and another completed and occupied which had been commenced in 1895. The balance sheet shows that among the assets, patents and franchises are held at $8,000,000; factory plants, $3,400,000; stocks and bonds, $8,545,796; inventories, $4,034,753. Among the liabilities, capital stock figures at $34,712,000 and bonds $8,000,000. The excess of liabilities over assets is $12,957,413. During the year $349,919.20 were paid out for patents and patent expenses, this amount being taken from the earnings of the year. The report of President Coffin states that the business of the company has suffered during the past year in common with that of other manufacturing enterprises, from the disturbed financial and political conditions which have prevailed during a considerable portion of the time. As a result, the shrinkage of orders received by the company was very marked, especially during the latter half of the year, and the amount of work in progress and unfilled orders on hand is considerably less than a year ago. With return to normal commercial conditions, President Coffin expects a corresponding revival or the business of the company, and reports that the volume of the business secured for the first three months of the current year is slightly in excess of that of the same period in either of the three previous years.

General Meeting of A. I. E. E.—The annual general meeting of the American Institute of Electrical Engineers, to be held at Eliot, Me., during the week beginning July 26. promises, for several reasons, to have a large attendance. The location is accessible, being less than two hours distant from Boston, and accommodations are plentiful in Eliot or at summer hotels in the vicinity. The town of Eliot is situated on the beautiful Pisquataqua and the surroundings will be found ideal by those who wish to combine a week's outing with attendance on the meetings. Above all, the visitor will have an opportunity to examine and become acquainted with the aims of the Greenacre movement, the successor of New England intellectual movements of other days identified with the name of Emerson, Ripley, Olcott and others. The Greenacre conferences were instituted by Miss Sarah Farmer, the daughter of the late Prof. Moses G. Farmer, so well known as an electrical pioneer; the meeting of the Institute at Eliot is in connection with an electrical conference to commemorate the fiftieth anniversary of his entrance on electrical work. The leading idea of the Greenacre conferences is "peace and unity, to be sought through the presentation and comparison of the constructive phases of thought in every field of study, the advantages of summer rest and recreation of a rational character being combined with rare opportunities for the development of the higher nature." In its two years of existence, the conference has had the collaboration of many leaders in the higher realms of thought, among whom are Profs. Jos. le Conte, E. S. Morse, John Fiske and A. E. Dolbear; Hon. Carroll D. Wright, Hon. Neal Dow, Dr. E. E. Hale, Mr. Frank B. Sanborn and many others. One course of conferences, on the history and philosophy of religion, the Vedanti philosophy and Oriental religions, was participated in by several learned teachers from India, two Hindoos and a Parsi. This school will be continued during the present season with lectures on Buddhism, Hinduism, etc., from native teachers. A school of music carried on in connection with the conferences will occupy its new building this summer. The general course of lectures will be on Business Ideals, Peace and Arbitration, Education, Evolution, Sociology, Psychology, Invention with special application to electricity, Nature, Art and Comparative Religion.

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The Berliner Patent.

As we go to press, announcement is made of the decision of the U. S. Supreme Court in the Berliner case, which decision is in favor of the American Bell Company. In the absence of the full text of the opinion, its exact bearing cannot be stated, but the telegraphic abstracts indicate that the question as to the validity of the Berliner patent is left open for future adjudication. The history of the Berliner patent up to the present is not a pleasant one to read by those who would like to retain the respect for government which their duty as good citizens calls for. Two courts have decided that there are no evidences of fraud or corruption in the delay of the issue of the patent, but the record of blundering and incompetency on the part of govermental officials is scarcely less disheartening than would have been the establishment of such charges.

On the one hand was a corporation of immense wealth, with its interests looked after by men of vast ability and consummate skill in their respective departments. On the other hand was a Patent Office whose chief office is the spoil of politicians and often occupied by a mere political hack; and whose technical staff consists of overworked and underpaid officials, most of whom merely regard their position as a stepping stone to something better in private life. Is it any wonder that, under these conditions, the issue of the Berliner patent could be delayed 14 years, even without resort to methods coming under the ban of law? The independent telephone interests have to share some of the blame for the outcome of the recent abortive attempt to annul the Berliner patent. From the beginning of the suit just ended, it was apparent that the government as plaintiff was handicapped, for it could not sue on the entire merits of the case. Having granted the patent, it could not throw the onus of dilatory action in the Patent Office on the defendant, nor could it expect consideration for its claim of error relating to the identity of the 1880 and 1891 patents. The suit should never have been instituted by the government, for it has only resulted in a delay of almost six years, and left the question to be recontested by independent telephone interests.

Electric Pumping.

During the past several years, without attracting much attention, considerable work has been done in electric pumping, and the article on this subject in another column gives an excellent account of the present stage of advancement of this branch of electrical application. As the writer of the article designed and installed all of the plants described except one, the information given can be accepted as authoritative. It is worthy of note that this is one branch of electrical engineering in which the work has mostly been executed by other than the engineering staff of electrical manufacturing companies, which perhaps accounts for the little attention that has been attracted to it.

A Private Residence Electrical Installation.

Through the courtesy of Sir David Salomons, the owner, we are enabled to present in this issue a description of a private residence lighting plant which has a double distinction of being the pioneer installation of the kind in the world, and the most complete in all of its details in existence. It may be of interest to the reader to know that the plant at Broomhill, together with experiments in electric lighting undertaken in connection with it, the laboratory apparatus, projection lanterns, etc., represent an outlay of not far from a half million dollars. This vast expenditure has not been without benefit to the public, for in the course of the development of the installation to its present state, many problems in electrical engineering have been encountered and solved. The storage battery was taken up at Broomhill in its veriest infancy, and the success there achieved in its use undoubtedly had much to do with the rehabilitation in recent years of that much abused auxiliary. The "booster" was developed at the same place, having been worked out some years before the English patents of 1885 on it were issued to Sir David Salomons, and the description printed elsewhere discloses many devices worthy of general adoption for use in similar installations. The only work in English on the practical operation of storage batteries, "The Management of Accumulators," is the result of experience gained by the author in the working of the Broomhill plant. In addition to this volume, Sir David is the author of two others on the practical aspects of isolated electric light, these with the first mentioned forming a series entitled "Electric Light Installations." Two often when men of great wealth indulge in scientific pursuits, it is merely for the personal gratification of a hobby. The owner of the Broomhill plant is an exception to this characterization, the motive to assist in electrical development, both scientific and practical, being the controlling factor in all of his work.

Safe Cracking by Electricity.

The article in our March issue by Lieutenant Rodman on "The Application of Electricity to Bank Burglary," has had an entirely unanticipated effect. Intended for electricians amply competent to judge of the narrow application of the electrical method of burglary, and to whom the principles involved are besides entirely familiar, the article appears to have had a startling effect in another direction, for we learn from vari-

ous sources that it has created a veritable panic among bankers. In order to keep within bounds some of the fears excited by the supposed great menace to the security of safes from the electrical method of attack, or, at least, to clearly define the conditions to which it is subject, the following calculations may be of service.

Lieutenant Rodman states that the amperage required for the electrical perforation of safes is from 250 to 350, the voltage being from 50 to 80. The source of current may be from public electrical supply mains, a storage battery, a generating plant expressly installed with burglarious intent in a neighboring building, or from a trolley circuit. Assuming 350 amperes as the current necessary for the purpose, this corresponds very nearly to the current taken by about 700 incandescent lamps at the ordinary voltage. This amount, it is perhaps needless to say, could not be drawn from the mains of the lighting plant of the largest office building in which a bank might be located, without immediately attracting the attention of the dynamo attendant. In the lack of an independent source of supply, the operations of the burglar electrician are therefore limited to a bank building taking its current from street mains. This would be feasible so far as the quantity of current is concerned, for in any city of considerable size, a sudden increase of load to the extent indicated would not attract attention at the central station; moreover, as a No. 1 or even No. 2 wire would carry the necessary current for the limited time that would be needed, it is quite probable that any street connection to a bank building would be of sufficient capacity for the purpose here discussed.

Should a distributing main as large as, say, No. 1 wire ($\frac{5}{16}$ in. diameter), pass in the vicinity of the safe, the burglar electrician, if aware of its location, could make his attachment direct to it. Nevertheless, in almost every case he would have to obtain access to the main fuse in order to replace it with a wire that would carry the necessary current, and to do this would in turn require access to the lower premises. Should a main of the necessary size not be thus available, the tap would have to be made direct to the street connection, which again implies access to the lower premises. This at once suggests a mode of protection—guard access to the street connection and main fuse, and if the latter is large enough for a normal current of 350 amperes, replace it during the night with one only large enough to carry the night lights.

It has been suggested that in the lack of an electrical service in a bank, a storage battery might be introduced and utilized. This, however, is out of the question, as from 25 to 40 cells would be required in order to obtain the necessary voltage, each containing not less than, say, 5 sq. ft. of positive surface for a rate of discharge (350 amperes), 10 times greater than the normal rate of pasted plates. If the plates are 10 ins. $\times$ 10 ins., nine would be required for each cell at the above rate of discharge, and the weight of a cell of these dimensions that could be bought on the market would be over 150 lbs. Even with a still more abnormal rate of discharge, the plates of a battery required even for 50 volts, could not conceivably weigh less than 500 lbs. with receptacles and without the electrolyte, which latter would have to be mixed and added on the premises, this necessitating a considerable expenditure of time and access to a supply of water.

The third method suggested is the installation of an electrical plant in a neighboring building for the generation of the necessary current. A 30-kilowatt dynamo would be required, or one of, say, 40 kilowatts if a 110-volt machine were purchased to avoid the suspicion that might be excited were a dynamo of an unusual voltage ordered. Such a machine could be bought for less than $800; the boiler and engine would cost less than $1500, or the entire generating plant in place, including rheostat, etc., would not require an outlay to exceed $3000; an economically-minded burglar, by purchasing second-hand apparatus, could reduce this to about half that amount. It is improbable, however, that a generating plant would be set up for this purpose, as it would be both cheaper and simpler to install a storage battery, which could be easily smuggled, cell by cell, already charged, into a neighboring building. Such a battery could be purchased for $2000 or less. A fourth method suggested is to obtain the necessary supply of current from a trolley wire. At the voltage usually employed, 350 amperes would correspond to a load of about 250 horse power or equivalent to not far from twenty cars. Even on a large electric railway system this would, in the dead of night, attract attention at the power house, and result in an immediate inspection of the line. Besides, the motormen would become aware of such an unusual draft of current at night by a slackening of speed, and would be on the lookout to determine the cause. A current of street railway voltage would also increase the difficulties of manipulation.

Should the burglar be fortunate enough to find available a sufficient supply of current, let us see what material he would require for his operations. The carbons could easily be carried in the pocket, and the block of chalk to confine the heat and conceal the glare would probably not need to be over 18 ins. square and a few inches thick. One of our readers, by-the-way, who undertook to perform the experiment described by Lieut. Rodman, dispensed with the chalk oven, with the result that he was incapacitated for duty for some days through his eyesight being affected by the blinding glare set up by the arc. Supposing a cable conductor for a lead of 200 ft. to be taken along, this would weigh, if of No. 1 wire, about 125 lbs., and form a bundle that could not be well concealed about the person even if in two sections. As the voltage has to be reduced to 50 volts at times, and as the street voltage is never less than 110 and is usually 125, for the latter voltage a resistance capable of absorbing 75 volts would be necessary; not over a few pounds of German silver wire would be required for this purpose, or a rheostat of very moderate dimensions. The accomplished burglar electrician would perhaps prefer a water rheostat, which he could easily improvise on the premises, merely carrying with him the terminal plates.

Assuming sufficient electrical skill on the part of the burglar, it will be seen from the foregoing that electrical safe cracking involves no peculiar difficulties if an attachment to a street main is possible, or if current can be obtained from a storage battery or a generating plant in a neighboring building, such a plant either being expressly installed for the purpose, or one utilized that had previously been employed in that location for legitimate purposes. A high order of electrical skill would, however, be demanded, for if the operation were not properly conducted, enormous drafts of current would result from short circuits and clumsy manipulation, which might lead to detection through the glare of the arc and otherwise. Assuming that the safe has been electrically perforated, it does not at all appear to follow that its contents are at the mercy of the burglar. The locking mechanism would be most effectually and permanently secured by welding or disabled by melting, should any part of it be encountered by the arc. Possibly a safe might be opened by the interior locking mechanism being rendered accessible through a perforation; otherwise, access to the contents would have to be through such perforations, and it is difficult to see how these, in limited time, could be made of sufficient diameter to be servicable, particularly in the case of a large safe or vault,

CONSTRUCTION OF A GALVANOMETER.

BY EDWARD E. SHELDON.

Of the several types of galvanometers, there is, perhaps, no other which covers so wide a range of usefulness as the D'Arsonval, and certainly there is no other which can take its place in the dynamo room, for, owing to its intense magnetic field, it can be used in close proximity to dynamos, and it is not affected by wires carrying heavy currents, as are other types. It is a dead-beat instrument, enabling readings to be taken very rapidly, and it has not the delicate suspensions of other forms, making it a convenient portable instrument. The form which it is the purpose of this article to describe will be found to meet the requirements of all but the most delicate tests, when, of course, a high priced instrument is essential.

The magnet for this instrument is built up from sheets of 1/16 in. steel of the form shown in Fig. 1. Six of these plates are bolted together, making the completed magnet 3/8 in. thick. The plates should be cut or forged from the best steel and bolted together; while in that position they should be carefully finished, after which they may be taken apart and tempered, but care should be taken to mark them with a prick punch so that they may be reassembled in the same relative positions. To temper them, heat a large flat piece of iron and lay one of the pieces on this. When it becomes a cherry red, quickly plunge it, points first, into a pail of cold water, repeating the operation with each of the remaining pieces. After being tempered they may be magnetised by means of the usual coils about their poles. Each should be magnetised separately. They may then be reassembled and polished.

A base should be provided of hard rubber or well seasoned hard wood, and should be turned, as shown in Figs. 1 and 3. Cut a mortise in the center which shall be a snug fit for the magnet and allow it to go 1/4 in. deep. Cut two strips of 1/16 in. brass, 3/8 in. × 3 5/8 ins., and at one end of each turn up 3/8 in., forming a right angle. Drill through the short limb of each for a screw to fasten it to the base; at 2 7/8 ins. from the base of these L-shaped pieces, drill a 3/16 in. hole and bolt one to the back of each limb of the magnet. Place the magnet in position and fasten by screws to the short limbs of the brass strips.

A pattern must be made for the standard shown in Fig. 1, and one cast from brass. It will be well to have this 1/2 in. longer than shown, as experience indicates that the suspension is improved by being made slightly longer. The casting should be finished, all holes drilled and secured to the base, as shown in Fig. 3. A brass button should be turned up and a slot cut therein to receive the end of a piece of 1/16 in. sheet brass, 7/8 in. wide, which should be soldered into this slot. A 3/16 in. hole is drilled through the end of this strip, 1 1/2 in. from the face of the casting, to the top of which this button is screwed. A milled head screw, 3/16 in. in diameter and 1 5/16 in. long, is provided with two milled nuts, and has a small hook, made from No. 26 brass wire, soldered to its end. This screw is passed through the hole in the brass strip with one nut on each side of the strip. The position of the button, strip, screw and nuts is shown in Figs. 1 and 2.

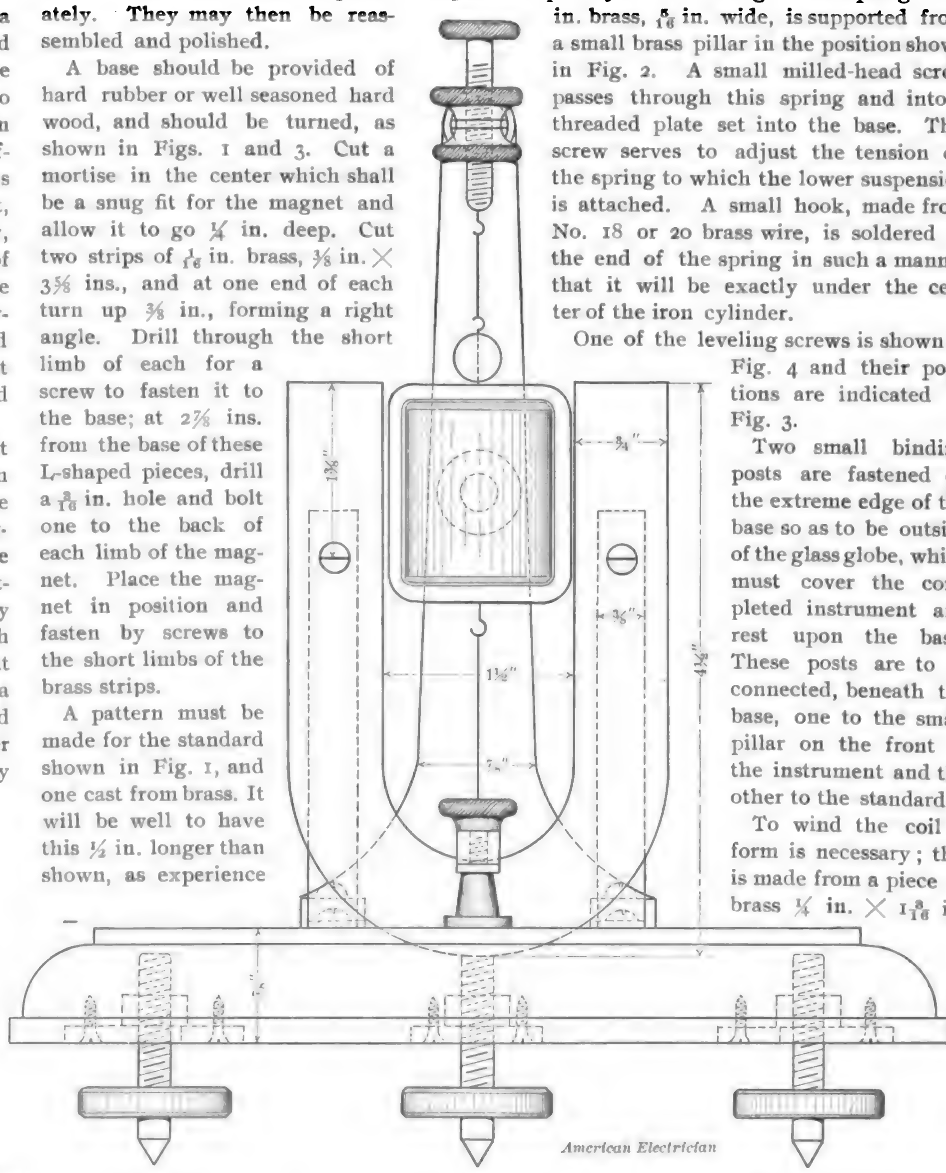


FIG. 1.—D'ARSONVAL GALVANOMETER—FRONT VIEW.

The cylinder shown in Figs. 1, 2 and 3 is turned from soft iron, and is supported by a brass arm from the standard. Its position is plainly shown in Fig. 2. A spring of 1/32 in. brass, 5/16 in. wide, is supported from a small brass pillar in the position shown in Fig. 2. A small milled-head screw passes through this spring and into a threaded plate set into the base. This screw serves to adjust the tension on the spring to which the lower suspension is attached. A small hook, made from No. 18 or 20 brass wire, is soldered to the end of the spring in such a manner that it will be exactly under the center of the iron cylinder.

One of the leveling screws is shown in Fig. 4 and their positions are indicated in Fig. 3.

Two small binding posts are fastened on the extreme edge of the base so as to be outside of the glass globe, which must cover the completed instrument and rest upon the base. These posts are to be connected, beneath the base, one to the small pillar on the front of the instrument and the other to the standard.

To wind the coil a form is necessary; this is made from a piece of brass 1/4 in. × 1 3/16 in. × 1 1/2 in. with a plate 1 1/2 in. × 1 15/16 in. fastened by screws, to each side. The corners, over which the wire bends, should be slightly rounded. Tho wire to be used should be silk-covered and should not be larger than No. 36 B. & S., and the finer it is the more sensitive will be the instrument. Wind it carefully and in even layers, using no paper or other insulation aside from that on the wire. The completed coil should be 1 7/16 in. wide, but the exact length is immaterial. Place the form with the wire still on it, in an oven and heat until as hot as the hand can bear; then with a clean soldering copper, drop on paraffine until the wire is completely saturated with it. After it has cooled, carefully remove the coil from the form and trim off the superfluous paraffine.

Cut from very thin copper, such as a leaf from a dynamo brush, two plates 1/4 in. × 5/8 in., and to the center of one solder a small hook made from No. 26 brass wire; to the other one solder a similar hook, but with a shank 7/16 in. long. With a fine silk thread bind one of these plates to each end of the coil, being careful to place a thin piece of mica between the plate and the coil, and to have the hooks exactly in the center. To

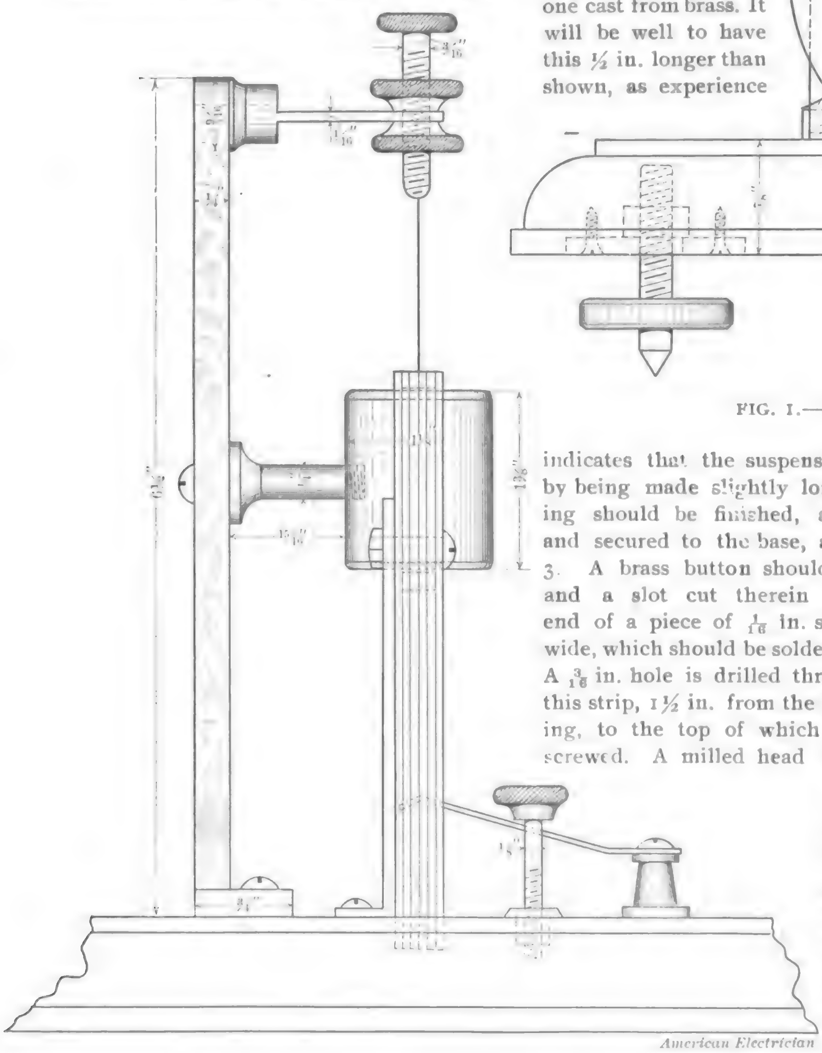


FIG. 2.—D'ARSONVAL GALVANOMETER—SIDE VIEW.

each plate solder one terminal of the coil and shellac all but the hooks.

A mirror ⅜ in. in diameter is now to be cemented to the shank of the longer hook by means of a little thick shellac varnish. This mirror may be made from a microscope cover glass, and silvered by the following formula: Take 100 parts by volume of a 10 per cent. solution of nitrate of silver and add, drop by drop, a quantity of ammonia just sufficient to dissolve the precipitate formed. Make up the volume to ten times the amount by adding distilled water. Dilute a 40 per cent. solution of formaldehyde to a 1 per cent. solution. Dip the glass, previously cleaned with chamois, in a mixture of two parts of silver solution to one of formaldehyde. After ten to fifteen minutes wash in running water and varnish the back. The silver will adhere to both sides and must be removed from the face.

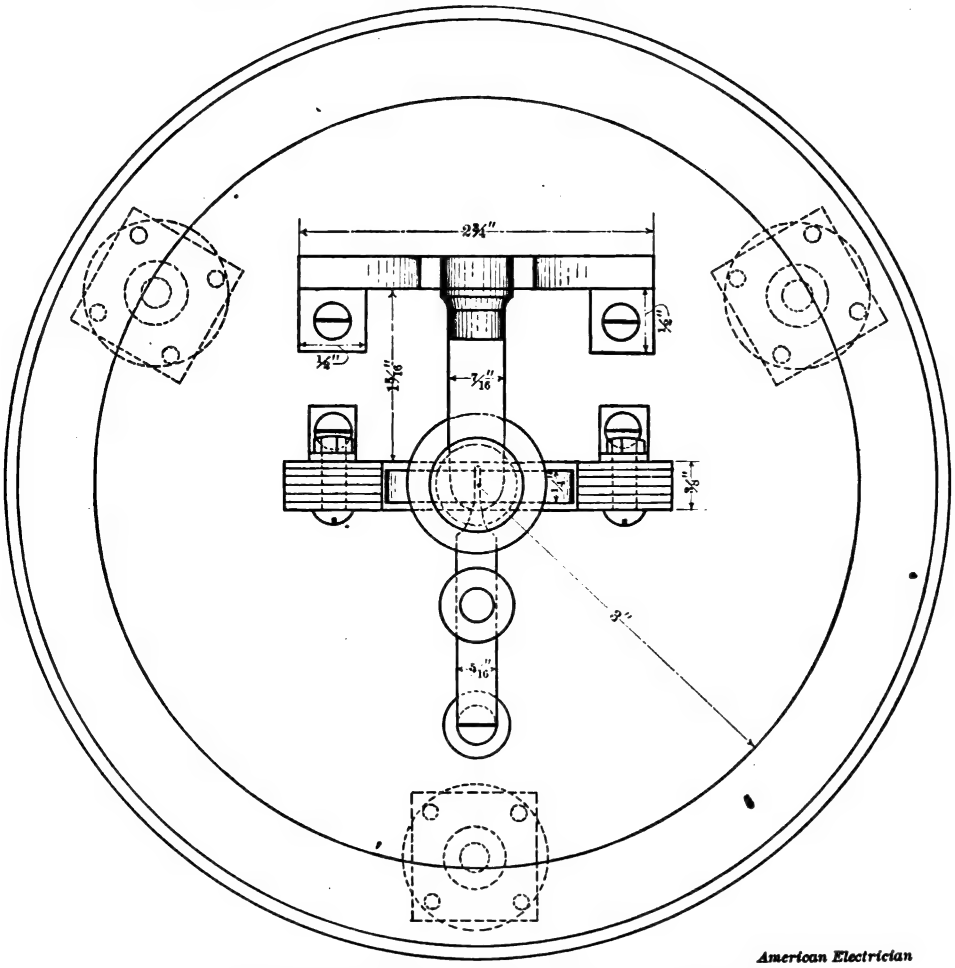


FIG. 3.—D'ARSONVAL GALVANOMETER—PLAN VIEW.

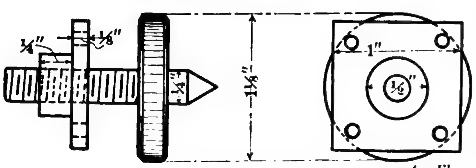


FIG. 4.—LEVELING SCREW.

The coil, with its mirror, is now to be suspended between the hook on the screw at the top and the one on the spring at the bottom. The suspension is a very fine phosphor bronze wire or strip, and can best be obtained from the makers of such instruments. For the suspensions take two pieces of the proper length and form a small loop in each end of each. These loops must fit snugly over the hooks. Suspend the coil by these, having the mirror at the top. Adjust the instrument so that the suspensions are taut with some little strain on them from the lower spring. See that the coil swings freely between the magnet limbs and the iron cylinder and is parallel with the front of the magnet.

The instrument is then complete, but should be provided with a reading telescope or a scale and lamp, which is not quite as convenient, but is simpler. It consists of a board 2 ft. long attached to a base and carrying a scale at about the same height as the mirror on the galvanometer. Just below the center of the scale is a ¾ in. hole with a fine wire stretched perpendicularly across it. A lamp is placed with its flame opposite the hole and behind it and, by means of a suitable lens, the image of this wire is thrown on the mirror and reflected back to the scale, thus acting as a pointer. An ordinary magnifying glass will answer in the absence of a better lens. The scale should be about 2 ft. from the galvanometer and the lens should be between the two, rather nearer the scale. The exact positions must be left to experiment in each individual case.

Debate on Municipal Ownership.

The third annual debate of the Engineers' Association and the University of Wisconsin Engineers' Club was held at Madison, Wis., Apr. 3, the question being "Would it be advisable for the city of Madison, under present conditions, to establish and operate an electric lighting plant for municipal purposes?" The judges, Profs. Bull, King and Whitney, decided in favor of the negative.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

WEAK FIELDS IN RAILWAY MOTORS.

When the field magnets of a railway motor become wholly or partially short-circuited, the result is what is known as a weak field. The back electro-motive force of the armature falls off, and an enormous current flows in order to produce the necessary torque to drive the motor in accordance with the laws connecting speed, number of armature conductors and number of efficient lines of force.

If the field is only slightly weakened, the result will simply be a high speed, but if it is largely weakened, the current will be so great and the sparking so excessive that serious damage is done. The head of the armature is often burned full of holes, caused by the flaring arc at the brush holders, which often jumps a distance of two or three inches; and should it be unfortunate enough to strike a shorter path to ground in so jumping, it will hold in that position and burn out anything in its way.

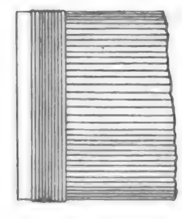


FIG. 1.—INSULATION OF END OF COMMUTATOR.

For this reason it is particularly necessary to insulate the commutator of a railway motor in a very high degree, and make the path from the bars to the head of the armature, or to the metal portions of the casing, as long as possible. This has been appreciated by the makers of all modern electric railway motors, and the number of devices that have been used to mitigate this evil are many. Some of these are subject for description here and others are arrangements that are not generally practiced, but are nevertheless very effective.

The first method that was used to render the path from the commutator bar to the iron sleeve of any length, was to wind shellacked string tightly to end of the commutator, as shown in Fig. 1. This is a sufficient method in the case of railway generators, because if a fault should occur which would necessitate the protection of such a device as this, it would be noticed immediately and rectified. On a railway motor, however, it is very insufficient because a weak field can exist without the knowledge of the motorman or the inspectors, and an arc once struck will quickly burn away the string.

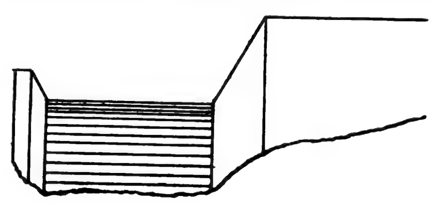


FIG. 2.—INSULATION OF END OF COMMUTATOR.

A second method and one which is now largely used, is to place over the ends of the commutator bars a vulcabeston collar as

shown in Fig. 2, thus making the arc climb outwards for the space of ¾ in., then longitudinally about ½ in., and then down again, a path which it is not very apt to choose; and indeed this device is very effective in preventing the commutator from flashing over to the shaft or quill. Some makers prefer to enlarge the mica collar which insulates the bars from the end of the quill, as shown

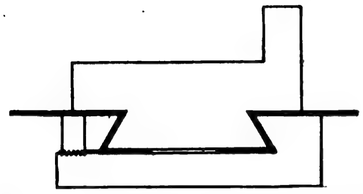


FIG. 3.—INSULATION PROJECTING AT ENDS OF COMMUTATOR.

in Fig. 3, and this is effective, but it has the disadvantage that the projecting mica is rather a tender substance and liable to be bruised and broken in handling.

None of these devices prevents the flashing arcs liable to occur simultaneously with weak fields, from jumping to the sides of the case. In some motors this very frequently happens and therefore the writer strongly recommends lining the case with asbestos in the region of the commutator. This has been tried in the cases of some of the older types of armatures in which trouble of this nature was anticipated, and it is worthy of notice that although the weak field did occur and the commutator was severely burned, yet there was no evidence that the armature had found a short path to ground by way of the case or the shaft.

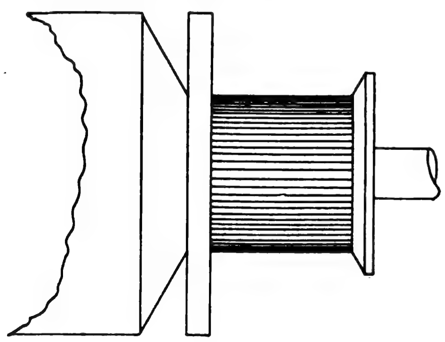


FIG. 4.—VULCABESTON COLLAR ON END OF COMMUTATOR.

The other end of the commutator is usually some distance from the armature head, but the fact that armatures sometimes come in burned full of holes, on account of this destructive flaring, suggests more protection on this side. Most of the commutators as now built have a liberal length of bar, and are amply able to carry a vulcabeston collar of ⅜ in. or ½ in. in thickness. This may be fastened on as shown in Fig. 4, and although it does not improve the looks of the armature, it will be found very effective in keeping these flashing arcs from burning holes in the armature head.

The armature with a long commutator lug which extends radially outward until it equals the diameter of the armature, is much to be recommended in a railway motor. The arcs originate at the brush holders, and find the adjacent surfaces of the same potential, and, therefore, will not maintain themselves should they happen to be deflected against them. This is one of the best methods of keeping flaring arcs out of the armature head.

On some armatures, where the provision made for these flaring arcs is nothing more than a string winding, the security can be very much improved by the following device: Wrap the string winding about a piece of asbestos, as shown in Fig. 5. This ribbon of asbestos should be all of one piece; the reason for this is apparent when it is seen that the asbestos is folded back over the string. The asbestos ribbon is secured by means of a few turns of wire, as shown in Fig. 6. The wire is twisted up so there is just room to slip the edges of the ribbon under it, and when this is worked in place the wire is tightened by twisting and finally cut off close and soldered. The result is that the string is not only reinforced by the asbestos seat, but is protected against fire by an asbestos envelope. Such a protection as this is advisable on either end of a commutator bar, and will be found very efficient. A coat of shellac will improve the asbestos and keep it from fraying.

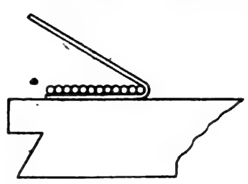


FIG. 5.—INSULATION OF END OF COMMUTATOR.

A weak field is usually accompanied by a great difficulty of keeping in the fuse at the large demand for current. A grounded motor will blow its fuse instantly, but one with a weak field is liable to blow its fuse on curves or slight grades or by throwing the controller on too far. If these symptoms occur therefore, it is much better for the conductor to lift the trap doors after the fuse has been replaced, noting the action of the motor. If one of them flares at the commutator as just described, it should be cut out and the run finished with the other motor.

In case of abnormal heating of a motor, the first thing to do is to see if the field has been weakened in any manner, and to this end the field coil connections should be carefully examined. On this subject, the following account of a case recently submitted to the writer will be of interest, as it illustrates several points bearing on the subject, and, particularly, the undesirability of placing blind confidence in a diagram of connections.

The electrician of an electric railway recently wrote that he had had considerable trouble with a car motor, both fields and armature of which ran very hot with vicious

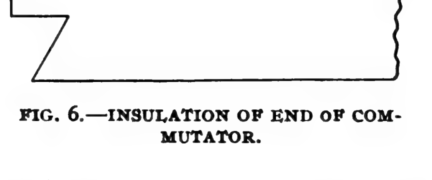


FIG. 6.—INSULATION OF END OF COMMUTATOR.

sparking at the brushes, though the commutator was in good condition and the brushes properly set; the motor also ran at a speed higher than normal. The old field coils were completely burned out, and new coils and a new armature put in; no better results, however, were obtained, but, on the contrary, the new armature was burnt out and the new coils were charred black.

The obvious reply was that there were defective or wrongly connected coils in the fields, but this was rendered improbable in view of the trouble continuing after new coils were put on, and of the positive statement that this point had been thoroughly examined into. The following reply was therefore made:

"The heating of the No. 12 Westinghouse motor in question must be due to excessive current passing through both field coils and armature, and not, in view of your statement, due to rubbing of the armature against field pieces. There might be two or even one bad field coil and the result would be as described—excessive heating. This, however, according to your statement, cannot be the trouble.

"Most probably it will be found on inspection that, for some reason, the upper and lower halves of the motor frame are not closed tightly together. It will be remembered that the Westinghouse 'Type 12' motor, which is the one in which the trouble occurs, hinges at the back of the motor, the lower half swinging down to expose the armature, etc.

"Now, in order to prevent the armature from striking against the bottom field when the armature bearings are worn, and to increase the safe life of the bearings, iron strips are sometimes placed in the joint between the upper and lower halves of the case. The result of this is an increase of the 'gap' between armature and the lower field, accompanied, of course, by a weakening of the magnetic field, and a corresponding weakening of the counter E. M. F. of the motor, resulting in a heavier motor current through both field and armature, which causes increased speed, decreased torque and increased heating as described.

"You may find this to be the condition causing the motor to heat, and if so, the reduction of the thickness of this strip, on its removal altogether, will obviate the trouble."

Some time later a report was received stating that it had been found that the diagram of motor connections used as a guide was incorrect, and two field coils had been discovered to be connected in opposition! The result of this was a weakening of the field, which led to a heavy enough current to char the fields and burn out the armatures.

DESIGNS FOR SMALL MOTORS.

BY CECIL P. POOLE.

My attention having been called to the fact that the designs for small motors which are being published in your columns prescribe somewhat "close fits" as to space along the shaft, boxes, etc., I think it advisable to remind readers that any details entering into the mechanical construction of these machines may be varied to suit individual fancy, so long as the size of the armature and field magnet core, the number of turns and size of wire in coils and the length of air-gap are not changed. The commutator and journals, journal yokes, shaft and such parts may be given any dimensions *not smaller* than those specified by the articles.

I have also had the suggestion made that the designs should include smooth-core armatures and multipolar magnets. The latter, of course, are not practical on such small machines. If any readers desire data for changing any one of my designs to a smooth-core machine I will be glad to furnish such information.

FAULTS IN MEASURING INSTRUMENTS.

The voltmeter, the ammeter, the recording wattmeter and recording ammeter, comprise the commercial measuring instruments in common use that are liable to faults. Inasmuch as these instruments are of many different types, it follows that each has its own peculiar faults, as well as faults that are common to all instruments of its class.

Taking first the voltmeter, there are three different types which are in common use. The first and by far the largest class is the one using an electromagnetic mechanism. The second class depends for its action on the expansion of a hot wire, and the third, the electrostatic voltmeter, depends for its action on the attraction between oppositely charged plates or surfaces.

The electromagnetic voltmeter abstracts a very small portion of current from the system to which it is connected, and is not, strictly speaking, an absolutely accurate instrument since, by abstracting this current, it changes the difference of potential of the two points across which it is connected. By making the instrument of great resistance and therefore miminizing this current, this inaccuracy can be reduced to so small a factor as to be neglected.

Any galvanometer can be calibrated and used as a voltmeter and therefore there are possible as many types of voltmeters as galvanometers. There must be in such an instrument two forces acting on the needle—one the deflecting force due to the electrical conditions, and the other an opposing force due either to a retractile spring or to gravity.

The faults that may exist in voltmeters of this class produce errors of deflection or prevent any deflection whatever. They may be enumerated as follows: 1°. Open circuits. 2°. Short circuits. 3°. Impediments to the free motion of the needle. 4°. Displacement of the needle or scale. 5°. Change or interference in the opposing force.

An open circuit within a voltmeter of the electromagnetic type prevents any deflection whatever and if it exists within the coil or coils of the instrument it is a most difficult fault to find, and should, consequently, be sought for at the contacts, binding posts or screws before unwinding the coil is hazarded.

There are a number of instruments on the market in which the binding post is directly connected to the delicate wires which lead to the coils of the instrument. The binding posts are liable to become loose and on tightening up the nuts the post turns as a whole, which will twist and break off this connection within the case. Such an arrangement can be greatly improved by soldering to the end of the wire a square washer which is countersunk in the wood of the casing, as shown in Fig. 1. Then the binding post may be turned without in any way endangering the joint. A soldered connection is not absolutely necessary in a voltmeter, but is to be desired for the reason that corrosion or the introduction of foreign matter into the joint may break the circuit altogether. When a voltmeter coil is saturated with paraffine, as is frequently done for better insulation, all of the joints should be soldered ones, for the introduction of the paraffine between them often causes trouble.

Short circuit in a voltmeter is liable to produce two effects, and will invariably produce one of them. This latter effect is to increase the current that the instrument takes. The other effect is to change the voltmeter deflection. If all of the resistance of the voltmeter is comprised in a coil which exerts the magnetic influence on the needle, as is often the case, and the nature of the short circuit is such as not to reduce the average length of turn, there will not be any appreciable effect on the deflection of the needle. The instrument will take more current and the coil will perhaps get hot and its change of resistance due to such heating may then introduce an error. The warning which is given in a case of a short circuit in such an instrument is the increased current that it takes.

There are many instruments now on the market which are constructed as shown in Fig. 2, in which a large external resistance, R, is connected in series with a voltmeter mechanism, M. A short circuit in R will increase the deflection of the instrument, and short circuit in M will diminish it. Such voltmeters as these are often provided with two scales and three binding posts, one of which, marked C in the diagram, is used with both scales, and the other two are used, marked B and A, with one or the other scale, as the case may require. The best way to determine the location of such faults is to measure the resistance of both R and M when the voltmeter is in good order, and make them a matter of record. If the voltmeter subsequently shows an error, this resistance should be remeasured and checked, and if a short circuit exists in either, it will be found at once and its extent may be determined. If both R and M are found to be intact, it is reasonable to suppose that some one of the other three faults enumerated in the first part of this article are influencing it.

Such instruments as require a large external resistance have usually an extremely delicate mechanism and are high grade instruments. There is on the market to-day an extremely popular instrument in which the needle is a portion of the electric circuit of the voltmeter. The writer at one time had rather a sad experience with short circuits with such an instrument which may be valuable as a caution to others. Consulting Fig. 4, the heavy inclosing line shown represents the outer casing of the instrument; M and R represent resistances as in Fig. 2. The wire placed in the binding post, D, was a little frayed, being a piece of flexible cable, and touched the side of the metal case. The deflection of the needle was unfortunately the wrong way due to reversed terminals, and it flew against and touched the side of the case. A circuit was made by the path, $DJKMC$, of so low resistance that the current resulting burned out the needle and some important parts of the mechanism—a peculiar ground, but one which has not infrequently occurred in other cases and one which should be guarded against.

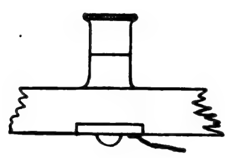


FIG. 1.—SOLDERED TERMINAL.

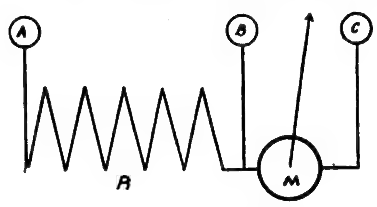


FIG. 2.—DOUBLE SCALE VOLTMETER.

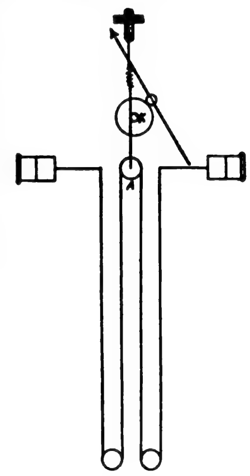


FIG. 3.—CARDEW VOLTMETER.

Impediment to the free motion of the needle is a typical mechanical difficulty. If the needle drags upon the scale and does not swing clear of it, if a pivot is broken or some foreign matter has become engaged in the mechanism, it ought not to be a task of more than simple inspection to discover it. Put the current on the instrument for an instant and suddenly remove it, and note whether the needle springs back to the zero mark promptly, or whether it sticks and requires jarring or knocking against the side of the case to make it do so. This being found to be so, the instrument must either be opened and the fault located, or it must be sent back to its makers for repair.

Most of the high-grade instruments are now sealed in order to prevent meddling with the mechanism, and the guarantee on such instruments becomes void if these seals are disturbed. Usually the external coil, R, is in an accessible position, but the mechanism, M, is defended by the seal.

Displacement of the scale or needle causes a constant error in instruments whose scale is uniform. The displacement of the needle may either be due to bending or by twisting on its pivot; the displacement of the scale may be due to a number of mechanical causes. The result will be apparent when no current passes through the instrument, by the presence of what is known as a zero error; that is, the needle is either one or the other side of the zero mark. Trouble from a bent needle is the most frequent, and often occurs in the case of instruments where this member is very delicate, and, unfortunately for the user of these instruments, this part of the case is sealed up, so that the trouble cannot be readily corrected.

The bending is usually caused by putting

a current through the instrument in the wrong direction, thus bringing the needle violently up against the sides of the case. A remedy which does not necessitate the opening of the case is to momentarily apply a voltage of 20 per cent. to 30 per cent. more than it will indicate, thus bringing the needle up against the other side of the case with a sharp blow and bending it back again,

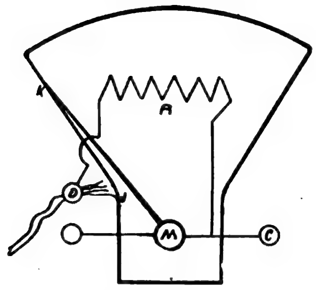


FIG. 4.—SHOWING SHORT CIRCUIT,

and by a series of judicious taps the error can be very nearly corrected. This is not, however, recommended as particularly good for the instrument. The writer has seen it tried a number of times, without apparent bad results, but it is certain that it is rough usage, and if the instrument is at all an important one, it is better to send it to the makers or to make a subtractive or additive correction when using it.

When the opposing force of the instrument is due to gravity, it is practically an unchangeable quantity, and therefore in an instrument utilizing this principle never has a fault of this nature. An instrument which uses permanent magnets, the strength of which forms a component of the moving force of the needle, is liable to vary in its indications due to the aging of the magnets, and its deflections will become less for a given voltage. The only remedy is recalibration and the subsequent use of the calibration curve, which indicates the error at any position of the needle, or a new scale which conforms to the new conditions.

There is no satisfactory remedy for the case where soft iron is contained in the moving parts. The susceptibility of this iron to magnetic influence is a variable quantity, and the deflection varies also in accordance therewith. This variation depends on the temperature and on the previous history of the piece of iron, and its motions are so erratic that it is practically impossible to apply either a calibration curve or a new scale, for the indications of such an instrument probably change every time the instrument is used and the fault is an incurable one. The only way to avoid it is to carefully select the iron when the instrument is built.

The Cardew or hot-wire instrument is liable to faults of an entirely different nature. The mechanism of this instrument is shown in Fig. 3. The wire, which is formed of a special platinum alloy, passes over little ivory pulleys, back and forth in a long brass tube and is connected to two binding posts; the wire is extremely fine, and necessarily so because of the desirability of very high resistance.

The pulley, *A*, is a movable one and is suspended in a sling by a little cord which takes a turn around the axle, *K*, and then passes upward to a spiral spring, the tension of which can be adjusted by a screw. This screw can be used in correcting any zero error which the instrument may have or acquire. The axle, *K*, connects with a multiplying mechanism to the axle of the indicating needle. The faults which are liable to occur in this instrument are mostly mechanical ones; short-circuiting is next to impossible and will be promptly followed by open-circuiting, due to the burning out of the fine wire. The mechanism may be impeded or the wire leave its pulleys, but neither of these is a probable occurrence.

One of the most frequent errors is that due

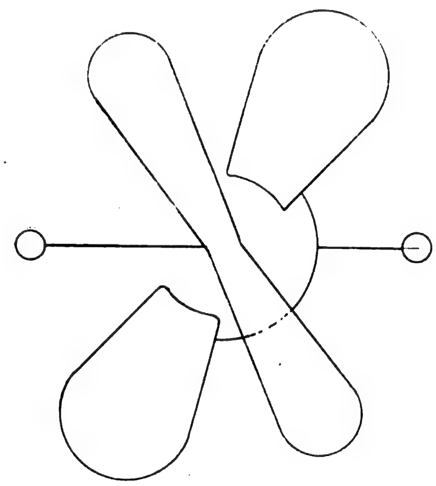


FIG. 5.—ELECTROSTATIC VOLTMETER.

to temperature of the outside air. The warmth of the hand placed upon the casing will produce an appreciable deflection, and in setting up such an instrument for accurate work, it is a good idea to place the long tube which contains the fine wire in a case packed with insulating material, such as hair felt or mineral wool. Unless the operator is an expert he should not attempt to restring a Cardew voltmeter, and that is practically all the repair the instrument will ever need, and will be the location of most of the faults that occur.

The electrostatic voltmeter has not yet been reduced to a commercial basis so that it can be generally used for the smaller voltages. It usually consists of a large vane which moves between two other vanes, and is normally held without them by gravity. It forms one terminal of the circuit and the vanes which receive it form the other. It is only used on extremely high alternating voltages where no other instrument would be applicable. The indications on these high voltages are fairly accurate, but on low voltages the deflections are so small as not to be easily read. Such an instrument, which is really a laboratory instrument, must be handled with the greatest care, adjusted to exactly level position and never touched when in use. The only fault that is liable to occur is the shifting of the needle or scale, or in terference with the moving mechanism. The counter-balancing force being gravity, it does not alter.

If the instrument is attempted to be removed while connected to the circuit, or jarred in any way, it is easily possible that the moving vane may touch one of the receiving vanes, constituting a short circuit, and the high voltage to which such instruments are usually connected will force through a current that will instantly destroy the instrument.

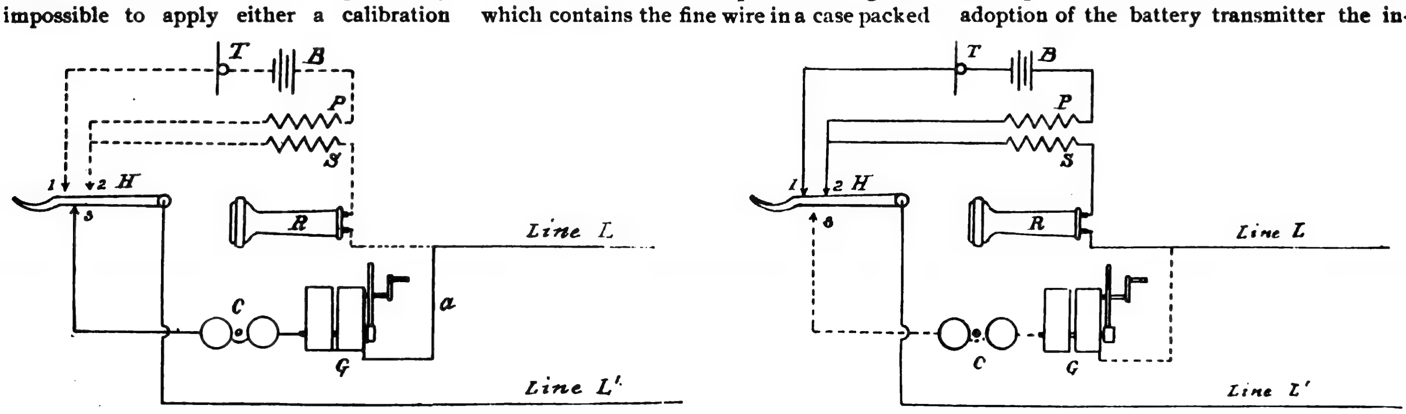
AMERICAN TELEPHONE PRACTICE.

THE HOOK SWITCH AND CIRCUITS OF A TELEPHONE.

BY KEMPSTER B. MILLER.

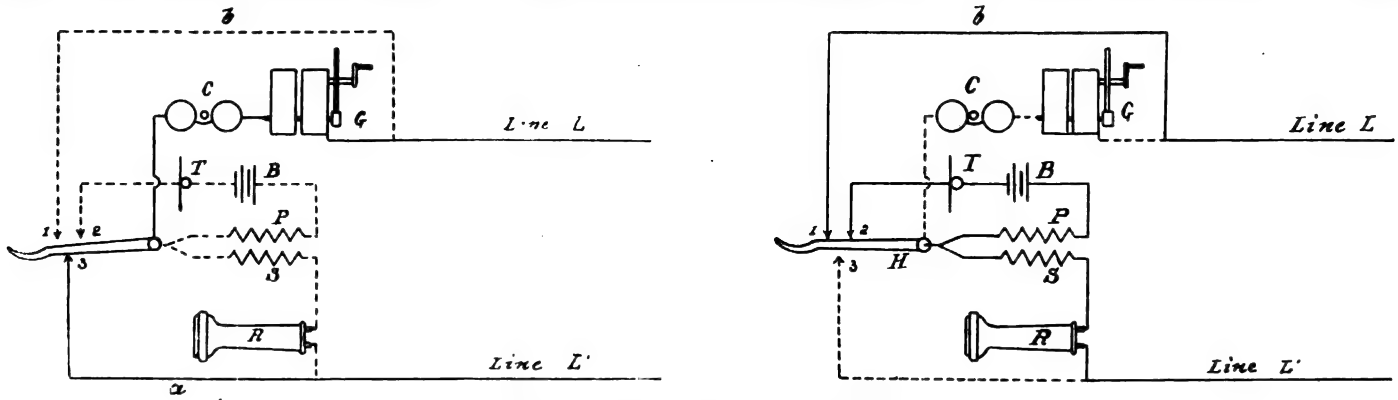
So far we have considered the talking apparatus and the calling apparatus separately. It is obvious that inasmuch as these are used alternately, some means is necessary for switching one or the other into the circuit. As an instrument must, when not in use, be ready to respond to a call, the call bell must, of necessity, be normally left in the line; and further, as the resistance and self-inductance of the call-bell magnets would be detrimental to the transmission of talking currents, the call bell must be switched out of the line when the talking instruments are in use.

At first more hand switches were used to accomplish this result, and even before the adoption of the battery transmitter the instruments were provided with an ordinary two-point switch, so arranged as to alternately close the line circuit through two branches—one containing a call bell and



FIGS. 1 AND 2.—TELEPHONE CIRCUITS.

generator, and the other the magneto telephone. It was soon found necessary to make this switch as nearly automatic as possible, as careless or ignorant users would frequently leave it in the wrong position. To attain this end, the switch lever was so designed as to be held by the weight of the receiver in contact with the calling circuit, but when released therefrom to be moved by a spring into contact with the talking circuits. Soon after, battery telephones having come into general use, it became necessary



FIGS. 3 AND 4.—TELEPHONE CIRCUITS.

to provide means for opening and closing a local circuit containing the local battery, the primary of the induction coil and the microphone transmitter. This was done in order to have the battery in use only when the telephone instrument was being used, and was accomplished by the addition of a single point with which the hook made contact when released from the weight of the receiver.

Fig. 1 shows the circuit of an ordinary telephone instrument. The hook, *H*, is shown in its depressed position as though under the weight of the receiver. In this position all talking circuits are inoperative, being open at the points 1 and 2, and are for that reason represented by dotted lines. A calling current from some other station coming over line wire, *L*, would pass through wire, *a*, to the generator, *G*, thence through the windings of the call-bell magnet, *C*, to the contact point, 3, through the lever of the hook switch and out through line wire, *L'*, or to ground, in case no return wire is used. This current will ring the bell. To obviate the necessity of this current passing through the armature winding of the generator, a shunt should be provided, as described in our last article. When the instrument is used for sending a call the crank of the generator is turned, automatically breaking the shunt around the armature and sending the current out over the line through the call-bell magnets of this instrument to those of the distant station.

In Fig. 2 the hook is shown in its raised position, as when released from the weight of the receiver. The circuit through the generator and call bell is inoperative, being open at the point, 3, and is therefore shown dotted. The local circuit containing the primary winding, *P*, of the induction coil, the battery, *B*, and the transmitter, *T*, is closed by the switch lever making contact with the points, 1 and 2. Current therefore flows in this circuit, and variations in the resistance of the microphone, *T*, cause corresponding variations in this current, which induce currents in the secondary winding, *S*, of the induction coil. These currents pass from the secondary coil to the point, 2, thence through the switch lever to line *L'*, to the instrument at the other end of the line, back by line *L* and through the winding of the receiver, *R*, to the secondary coil, *S*. An incoming current from a distant station follows the same path, and causes the diaphragm of the rceeiver to reproduce sound.

In Figs. 3 and 4 are shown circuits and apparatus for accomplishing the same results, but in a slightly different way. It will be seen that the circuit through the generator and call bell, and that through the receiver and secondary winding, are permanently closed, and are unaffected as to their continuity by the position of the hook switch. In Fig. 3 the hook is depressed, thus rendering operative the calling apparatus. The circuit through the instrument is now from line, *L* to the generator, *G*, thence through the call-bell magnets, *C*, through the switch lever to the point, 3, and by way of wire *a* to the line wire, *L'*. A current from the generator, *G*, of this station or another would pass through the secondary coil, *S*, and the receiver, *R*, were it not for the fact that the wire, *a*, affords a path of practically no resistance, thus short-circuiting the receiver and secondary.

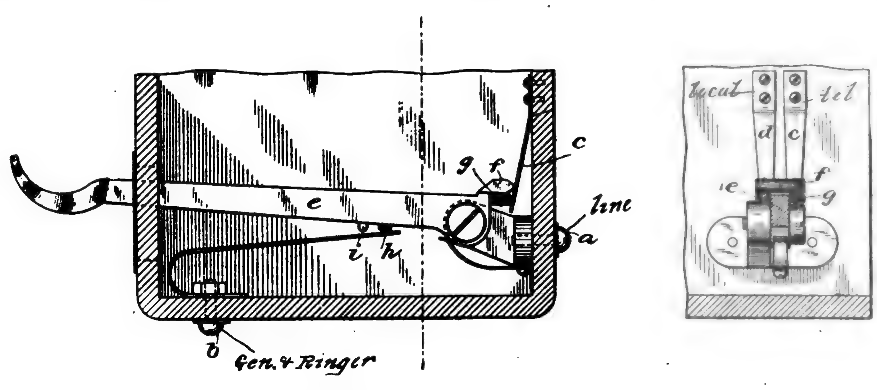


FIG. 5.—TELEPHONE HOOK SWITCH.

In Fig. 4 the hook switch is in the talking position and the generator, *G*, and the call bell, *C*, are rendered inoperative by virtue of the low-resistance path, *b*, being closed around them. The circuit through the instrument is now through the wire, *b*, contact point, 1, lever, *H*, secondary coil, *S*, and receiver, *R*. In the arrangement shown in Figs. 3 and 4 the local circuit is operated in the same manner as that shown in Figs. 1 and 2. The practice of leaving both the calling and the talking circuits permanently closed and of shunting one or the other out of the circuit is a good one, for if the hook does not make proper contacts the apparatus is still operative, although its efficiency is impaired.

Although the automatic switching apparatus is very simple, much care is necessary in its design and construction. The energy available for the operation of the switch is limited to that due to the attraction of gravity on the receiver, and it becomes somewhat difficult to so arrange the contacts that they will be firmly and positively made, and surely broken at the proper time. For this reason all the points of contact should be provided with platinum tips to prevent corrosion, and, if possible, a slight sliding action at the point of contact should be obtained. A sliding contact tends to clean the points and at the same time prevents particles of dust from keeping the two apart. The springs for restoring the lever and those serving as contacts should be so arranged that no movement of which the lever is capable will strain them beyond their elastic limit or to such a degree that they will eventually lose their tension or break. It is bad practice to have a contact point slide alternately over a conducting material, as of brass, and an insulating material, as of hard rubber, as small particles from either surface are sure to be carried upon the other surface, thus forming a partial electrical connection on the insulating surface and a defective connection on the brass or metal surface. Where a sliding contact is used much trouble is caused by the cutting of the two surfaces. The extent of this cutting, even where the pressure is very light and the movement very limited, is often astonishing.

In Fig. 5 is shown the hook switch now

almost universally used by the American Bell Telephone Company, and known as the "Warner switch." The hook lever is pivoted by the screw, *P*, and is provided with a lug, *f*, and a strip of insulating material, *g*, as shown. On the under side of the lever is an insulating point, *h*, and a contact point, *i*, A spring, *b*, secured to the generator box, under the lever, bears alternately upon the insulating point, *h*, and the contact point, *i*, and tends to press the lever into its elevated position. Springs *c* and *d* secured to the side of the generator box bear alternately upon the insulating piece, *g*, and the conducting piece, *f*, according to whether the lever is depressed or elevated. The spring, *c*, is connected through the secondary winding of the induction coil and the receiver to one side of the line. The spring, *b*, is connected through the calling apparatus to the same side of the line. The binding screw, *a*, connected with the lever, *e*, forms the terminal of the other side of the line. The local circuit terminates on one side in the spring, *c*, and on the other side in spring *d*. When the hook is depressed, point *i* is in contact with spring *b*, and the calling circuit is complete. Both the local circuit and the line circuit through the talking apparatus are broken at springs, *c* and *d*. When the hook is elevated, the calling circuit is broken at the point, *i*, and the local and line circuits are completed by the springs, *c* and *d*, and the lug, *f*.

This hook switch is as perfect as any on the market, and a study of it is interesting as showing a nicety of detail that can be appreciated only by those who have had practical experience in telephony.

INTERIOR WIRING.

ALTERNATE-CURRENT APPLIANCES.

Among the appliances that the interior wireman is likely to meet one of the most important is the balance coil.

It will be immediately understood that the object of the balance coil is to transform from a 220-volt system to a 110-volt three-wire system, and is used in precisely an analogous way to the rotary balance coil which was described in a former article, except, of course, that the static balance coil is used on alternating-current systems. A large transformer station distributes the current over one or more blocks at 220-volts, and the service wires come from balance coils connected as shown in Fig. 1.

The balance coil consists simply of a highly inductive resistance with a wire brought out from its electrical center. It usually is made by winding a coil of moderately heavy wire and surrounding it with iron punchings in precisely the same way as the ordinary transformer. The middle wire forms the neutral and the two mains form the outside wires, as shown in the figure.

The action of the balance coil is as follows: Suppose an extreme case of unbalancing. The effect of this is to increase the difference of potential on the *B* side and diminish it on the *A* side. The state of things now is as follows: The lamps on the *A* side need more current than will be supplied by the mains and the lamps on the *B* side require less. All of the current passes through the *A* side, but after it reaches the *B* side it divides and a suitable part goes down the neutral and through the *B* side of the balance coil. Thus the *B* lamps receive their proper quota of current. The *A* side of the balance coil becomes a secondary and supplies to the *A* lamps the extra current necessary. If the system is unbalanced the other way, *B* becomes a secondary and *A* a primary, and if exact balance occurs a very slight current will flow straight across the balance coil. This current is analogous to the current necessary to revolve the rotary balance coil.

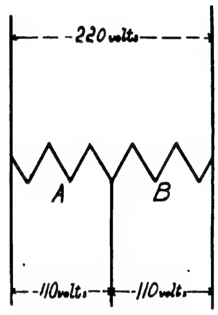


FIG. 1.—BALANCE COIL.

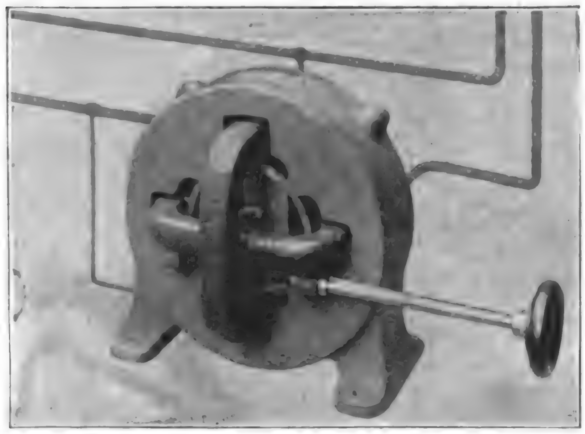


FIG. 2.—REACTIVE COIL.

An excellent balance coil can be made of a small transformer, and if properly wound it will take care of an unbalancing equal to its capacity as a transformer. The primary should be removed and the number of secondary turns doubled and a lead brought out from their electrical center. It will be seen that two similar secondaries can be used and this is often done. Care should be taken that they are connected so that a current passing from one to the other assists it in magnetizing influence. If one of the coils opposes the other, the pair will constitute a short circuit on the mains to which they are connected. Aside from this, the operator who is familiar with a three-wire system and the installation of transformers should have no trouble in installing the balance coil, and properly connecting it to the mains.

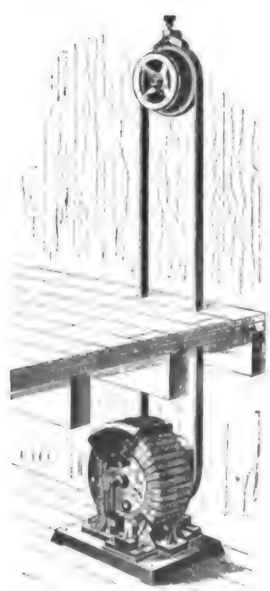
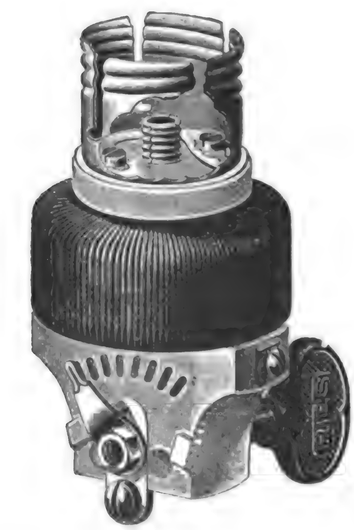


FIG. 3.
THEATRE DIMMER.

A most important appliance used in alternating-current work is the reactive or "kicking" coil. This appears in various forms, and consists simply of a coil, the ohmic resistance of which is very low and the inductive reactance very high and variable at will. There are four practical methods of adjusting the value of the inductance of a reactive coil. First, by cutting out portions, as in an ordinary rheostat; second, by introducing more or less iron into the circuit; third, by the presence of a closed secondary; and fourth, by changing the shape of the magnetic circuit so that the inductance of one part will be neutralized by that of the other.

A reactive coil built on this last principle is shown in Fig. 2. It consists of two coils in series, with a common core which can be rotated within. When the core is turned so that the coils assist each other in their magnetizing effects, the impedance is a maximum, and when they are turned so as to oppose each other in this respect, the impedance is a minimum. If arranged to short circuit after minimum impedance has been reached, the range will be from practically zero to a maximum.

The third method requires a little further description. If a heavy closed circuit is placed about a coil carrying an alternating current, heavy currents will be generated within it due to the transformer effect, and these currents will produce a field of force almost neutralizing the inductive effect of the primary coil and leaving only the resistance of the coil as a retarding factor. With a coil having a partly open magnetic circuit,



RIG. 4.—RIES REGULATING SOCKET.

this effect varies with the position of the closed secondary. Thus, this device has a wide range of regulation, and if it be arranged to short-circuit itself after the inductance has been minimised, the beneficial effects of the last case will be secured.

Fig. 3 shows a coil operating on these principles, which is largely used as a dim-

mer for theatre lights and for the general control of alternating currents. In such a device as this there are no contact points, and the regulation is accomplished by imperceptible intervals.

Another well known form of reactive coil operates on the principle of varying the amount of iron the circuit contains. The coil is wound on a hollow spool and the inductance is varied by adjusting the position of the iron core within. This device is not so good as the first, for the minimum inductance that can be obtained is larger in comparison, and thus its range is more limited.

Alternating-current arc lamps are often placed in series with an inductive resistance, sometimes called an "economy" coil, which holds back, but does not consume energy. These coils are usually varied in their reactive effects by means of a contact lever and studs.

An ingenious application of the inductive resistance is shown in the Ries regulating socket, designed by Mr. Elias S. Ries, the principle of which is simply the insertion of a variable inductance in series with the lamp.

The coil has a resistance of but a fraction of an ohm, but an impedance of many ohms. It consists of a ring of iron overwound with sixty turns of insulated wire after the fashion of a Gramme ring armature, each wire consisting of seven strands. A lever and seven contact points regulate the impedance, the strands making fast to the points. This socket is shown in Fig. 4, and will regulate the brilliancy of the lamp from a dull red to a maximum, the greatest reduction of current being 70 per cent. Its actual resistance is so low that on direct current circuits its regulating effect is inappreciable.

The Shallenberger shunt box is an application of the inductive resistance that deserves mention in this article. It is designed to protect lamps in series on a high voltage circuit, and consists simply of a

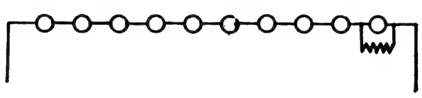


FIG. 5.—SHALLENBERGER SHUNT BOX.

resistance shunted across the lamp terminals, as shown in Fig 5. While the lamp burns, the terminal voltage forces only a very slight leakage current through the shunt. When the filament fails, the voltage at the lamp terminals rises very largely and forces a heavy current through the shunt, which is then in series with the main line, and replaces the resistance of the lamp. Although the increased current in the shunt box largely reduces the self inductance by reason of the saturation of the iron core, yet the voltage consumed by the shunt is always notably greater than that consumed by the lamp it replaces.

For this reason the failure of one series lamp equipped thus will dim the others on the same circuit. The advantage of the apparatus lies in the fact that it prevents both the general extinction which would result if such a precautionary measure were not taken, and a straining of the filaments in series as would follow the use of a paper or other similar cut-out.

STEAM ENGINE ECONOMICS.

To many practical men, the curves, tables of percentages and other similar data given in discussions of economical points concerning the steam engine, have little practical significance. What they want to know is the effect on the coal bill in dollars and cents, or the increase of power in horse power that will result. Of course, in a general article applying to steam engines of all sizes and efficiencies, it is impossible to give these data, but it would be extremely desirable to calculate at least one example, in order to bring out, in concrete terms, the savings involved. In this article two problems will thus be solved, relating to increased economy from the use of a feed-water heater and from a condenser.

We will assume an engine of 100 HP, worked non-condensing and without a feed-water heater, under which conditions the consumption of coal is $4\frac{1}{2}$ lbs. per horse power-hour. The coal will be considered to contain 90 per cent. combustible which, with a boiler efficiency of 70 per cent. corresponds to $14{,}500 \times .9 \times 7 = 9135$ available heat units per pound of coal. The cost of the coal will be taken at $2.50 per ton. Should these data not correspond to those which a reader has in mind, the following calculations can be made to conform by increasing or decreasing the results obtained by the necessary percentage.

Taking up, first, the case of the feedwater heater, we will assume the average temperature of the feed-water to be 65 degs., and that the exhaust steam will heat this feed-water to 200 degs. if passed through a heater. Consequently, there will be a saving with a feed-water heater of $200 - 65 = 135$ heat units for each pound of steam used. Referring to a steam table, we find that the total heat required to raise a pound of water from 32 degs. to steam of 100 lbs. pressure is 1184 heat units. Consequently, the number of units when the temperature of the feed-water is 65 degs. will be $65 - 32 = 33$ units less, or, 1151. As $4\frac{1}{2}$ lbs. of coal contain $4\frac{1}{2} \times 9135 = 41{,}107$ heat units, this corresponds to $41{,}107 \div 1151 = 35.7$ lbs. of water per horse power hour. Therefore the saving per horse power hour through the use of the heater will be $35.7 \times 135 = 4819.5$ heat units, which corresponds to $4819.5 \div 9135 = .527$ lb. of coal. Since the engine is of 100 HP, and running, say, for ten hours a day, 300 days in the year, the total saving will amount to $10 \times 100 \times 300 \times .527 = 158{,}100$ lbs., or 79 tons per year, which, at $2.50 per ton, gives a saving of $187. This is considerably more than enough to pay for a heater, whose uses, besides, will be extremely satisfactory to the engineer and increase the life of the boiler by reducing the strains that result from a cold feed.

The above calculation is entirely practical, and the saving which it shows can be obtained under the conditions cited, with the single proviso that the type of heater used is one not introducing any significant back pressure. The following example, however, should be taken as illustrative, for the reason that to add a condenser to an engine while using the original boiler pressure brings up questions of strains and valve working that would have to be considered for each case on its merits.

Taking the case of the above engine, we will assume that it cuts off at six-tenths stroke, and works against a back pressure of $1\frac{1}{2}$ lbs. above the atmosphere. Furthermore, we will assume that with a condenser the average back pressure is 4 lbs. above a vacuum, and that the engine be caused to cut off at four-tenths stroke. With an admission pressure of 100 lbs., the usual indicator card of a non-condensing slide-valve engine will give a mean prersure of 77 lbs. with a cut-off of six-tenths, and a mean pressure of 67 lbs. with a cut-off of one-half. Finally, we will assume that the engine will be run at the same speed in both cases.

The addition of a condenser under the above conditions will cause the following changes in the amount of steam used:

First, the amount of steam will be reduced in the ratio of the cut-offs, or will be $.5 \div .6 = \frac{5}{6}$ the original amount; second, the pressure above the atmospheric line will be less in the second case by $77 - 67$ or 10 lbs.; third, the condenser will add to the pressure in the first case the $1\frac{1}{2}$ lbs. atmospheric back pressure and $14.7 - 4 = 10.7$ vacuum, or 12.2 lbs. in all, making the mean pressure of the condensing engine $67 + 12.2 = 79.2$ lbs.

Assuming the steam to be worked at the same efficiency in both cases, the horse power will be increased in the ratio of 79.2 to 77 or from 100 to 103; the consumption of water will be reduced in the proportion of .5 to .6, or from 35.7 to 29.6 lbs. per horse power hour, or, on the basis of 100 HP, to $29.6 \div 1.03$ or 29.3 lbs. This makes a total reduction of $35.7 - 29.3 = 6.4$ lbs. or 18 per cent. We are informed by a manufacturer of surface condensers that the amount of power required to run this auxiliary varies from $2\frac{1}{2}$ to 5 per cent., depending upon the efficiency of the engine to which it is attached; assuming its horse power at the latter figure, we would have a net saving of 13 per cent. of coal, which would reduce the consumption per horse power hour from $4\frac{1}{2}$ to 3.915 lbs. As the water from the hot well will have a temperature of about 110 degs. this, by a calculation similar to the one above, can be shown to introduce a further saving over feed-water of 65 degs., of .27 lbs. of coal, making the total amount $3.915 - .27 = 3.645$ lbs. or a saving of $4.5 - 3.645 = .855$ lbs. per horse power hour. As the horse power is now 103, the total saving for 300 days of 10 hours would be $103 \times 10 \times 300 \times .855 = 264{,}195$ lbs or 132 tons, which, at $2.50 per ton., would amount to $330 per year.

The above calculation refers to a case where a condenser is added to an ordinary non-condensing slide-valve engine, and therefore of low steam working efficiency. If the comparison were made between an ordinary 100-HP non-condensing engine and a non-condensing engine of the efficiency that would be installed with a condenser, the saving would be much greater. If the non-condensing engine is of the Corliss type, the cut-off could be nicely adjusted for the less admission necessary for economy and to maintain the original power of the engine; with the ordinary slide valve, however, the adjustment could not be so satisfactorily made.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

The discovery by Oersted of the effect of an electric current on a magnet made, apparently accidentally, July 21, 1820, was communicated to the French Academy by a Swiss member on Sept. 11, 1820. Among the audience who listened to the reading of the paper was one who appears to have instantly grasped the enormous significance of the observation reported, and who immediately set to work to investigate its consequences. This was André-Marie Ampère, and one week later he presented a paper to the Academy, in which the entire foundations of the science of electromagnetism were firmly laid—an achievement which has been pronounced one of the finest in the history of the intellect.

André-Marie Ampère was born at Lyons, France, Jan. 22, 1775, the son of a merchant in good circumstances. Like Herbert Spencer, he received no school education, and, indeed, there is no evidence that his parents formulated any particular plan for his education. As a child, however, he astonished everyone by his precocity, particularly in mathematics; it is related that once, on recovering from a severe sickness during which he was allowed no solid food, when given a biscuit as a treat, he broke it up in little bits with which to reckon.

The child had shown no fondness for Latin until one day he happened, at the age of twelve years, on the mathematical works of Euler and Bernouilli, when his eagerness to read these treatises caused him to quickly become proficient in Latin, in which language the books were written. An omnivorous reader, he devoured everything that came in his way, including the great encyclopedia of Diderot and D'Alembert in twenty volumes, and from which work a half century later, he could quote entire portions, word for word.

During the Reign of Terror of the French Revolution, the father of Ampère, who had become a magistrate of Lyons, was proscribed and perished on the guillotine, Nov. 24, 1793. This afflicton almost took away the reason of the affectionate son and it was not until several years later that he recovered from the blow. Beginning with 1796 his diary reveals a romance, ending three years later, in marriage, almost idyllic as recorded; the death of his wife after but a few years of happiness saddened his entire after life, the bitterness being intensified by a most unfortunate second marriage in later years. From the first marriage there was born an only child, J. J. Ampère, to whom was transmitted much of the genius of the father, though exercised in another sphere. Ampère died June 10, 1836, and his last words illustrated his prodigious memory; deeply religious in feeling, he was offered consolation from Thomas à Kempis' Imitation, when he replied, "I know the Imitation by heart."

The first achievement of Ampère was the invention at the age of 18, of a universal language, the precursor of Volapuk. In 1802 he published a treatise on the theory of probabilities as applied to games of chance, and the notice which this received led to his appointment to a chair in a college at Lyons. In 1805 he was called to Paris as an instructor in the Ecole Polytechnique, where four years later he was elevated to the Chair of Analysis.

The first paper of Ampère on electro-magnetism, as stated before, was read before the French Academy of Sciences, Sept. 11, 1820. In this he showed that action exists equally in all parts of a conductor, and laid down the general law determining the direction of deflection of a needle, illustrating it by means of "Ampère's mannikin," which swims with the current and denotes the direction of the deflection with reference to its left arm. The solenoid was predicted in this paper as one of a number of devices he proposed to experiment with. On Sept. 25, Ampère gave the result of reseaches on the attractive and repulsive action of currents on each other. On Oct. 9, he laid down his theory of magnetism, in which each molecule is conceived to be surrounded by a closed electric circuit. On Oct. 30, he put forth the theory that the magnetic property of the earth is due to earth currents set up by the heat of the sun which, traveling from east to west along parallels to the equatorial circle, set up magnetic poles at the north and south poles of the earth. On Nov. 6, he showed how, by bending a conductor on itself, its external action is nullified, this experiment having been made to silence critics who would recognize no originality in Ampère's discoveries, but ascribed the effects to electrification as understood by older writers. Finally, on Dec. 4, Ampère gave a mathematical expression to the attractions and repulsions of electrical currents, which formed the basis of the present mathematical theory of electricity as developed later more thoroughly by others.

ANDRÉ-MARIE AMPÈRE.

As an estimation in which the work of Ampère is held in the scientific world, we quote the following from Professor Chrystal's article on "Electricity" in the Encyclopedia Britannica, which echoes the opinion of the scientific world.

"Physicists had long been looking for the connection between magnetism and electricity, and had, perhaps, inclined to the view that electricity was somehow to be explained as a magnetic phenomenon. Ampère showed that the explanation was to be found in an opposite direction. He discovered the ponderomotive action of one electric current on another, and, by a series of well chosen experiments, he established the elementary laws of electrodynamic action, starting from which, by a brilliant train of mathematical analysis, he not only evolved the complete explanation of all the electromagnetic phenomena observed before him, but predicted many hitherto unknown. The results of his researches may be summarized in the statement that an electric current, in a linear circuit of any form, is equivalent in its action, whether on magnets or other circuits, to a magnetic shell bounded by the circuit, whose strength at every point is constant and proportional to the strength of the current. By his beautiful theory of molecular currents, he gave a theoretical explanation of that connection between electricity and magnetism which had been the dream of previous investigators. If we except the discovery of the laws of the induction of electric currents, made about ten years later by Faraday, no advance in the science of electricity can compare for completeness and brilliancy with the work of Ampère. Our admiration is equally great, whether we contemplate the clearness and power of his mathematical investigations, the aptness and skill of his experiments, or the wonderful rapidity with which he elucidated his discovery when he had once found the clew."

From what precedes it will be seen that Ampère united the skill of the physical investigator with the analytical faculty of the mathematician, and this in a degree rarely if ever equaled. While the greater part of his work was in the branch of mathematical physics, his intellectical scope was by no means narrow. The latter years of his life were spent in an attempt at the classification of the sciences, and the reconciliation of religion and science was a frequent text.

To Ampère more than to anyone else belongs the title of "The Father of the Telegraph." In a paper read before the French Academy on Oct. 2, 1820, he sketched, incidentally, an electromagnetic telegraph in which the signals were to be indicated by the deflection of small magnets placed under electric conductors. Though entirely impracticable and put forth merely as a suggestion, the idea had fruition in the needle telegraph of Schilling and Wheatstone (1825-1837), which was the first telegraph to be put in practical operation, antidating the Morse system by several years, and yet largely used in Great Britain.

A number of amusing instances are related of Ampère's absent mindedness. On one occasion, while walking along the streets of Paris, his mind became engrossed on a mathematical problem. Unconcious of his surroundings, he began writing down formulas on the panel of an omnibus that happened to stop in front of him, and was amazed when his blackboard drove off just as he was about reaching a solution.

LESSONS IN PRACTICAL ELECTRICITY

DROP IN SPECIAL CIRCUITS.

Before again taking up the subject of alternating currents, several different systems of circuits will be considered on account of the misconception that exists in regard to the drop in their particular circuits, and also to show how simply complicated drop problems may be solved by applying numerical data to a given case.

In order to simplify the calculations and make them directly comparable, we will assume that the circuit in each case carries 5 lamps equally distributed, each taking one ampere, and that the resistance between each lamp is 1 ohm. Such a resistance, of course, would not be encountered in a practical case, and the reader may, therefore, if he chooses, consider it to be one-hundredth or one-thousandth of an ohm; by so doing the comparisons, which alone are the object of this article, will not be affected.

Fig. 1 is an ordinary electrical circuit fed from one end and having both wires of the same size. Since the resistance between *a* and *b* on the positive lead is 1 ohm, and the current for 4 lamps or 4 amperes is flowing through it, the drop (CR) on that portion of the lead will, therefore, be $4 \times 1 = 4$ volts; since 3 amperes flow between *b* and *c*, the drop on that portion will be 3 volts, or the drop on the positive lead up to the lamp, *b*, will be $4 + 3 = 7$ volts; similarly, the drop from *c* to *d* will be $2 \times 1 = 2$ volts, and the total drop to *d*, 9 volts; the drop from *d* to *c* will be 1 volt and the total drop to *d* 10 ohms.

On the negative lead the above drops are repeated; that is, the current of 4 amperes flowing from *b* to *a* gives a drop of 4 volts; 3 amperes from *c* to *b*, a drop of 3 volts; 2 amperes from *d* to *c*, 2 volts, and 1 ampere from *d* to *e*, a drop of 1 volt. Now, adding the drops on both leads from *a* to *b*, we have a drop of 8 volts to the lamp, *b*; a drop of $2 \times 3 = 6$ volts is added for the resistance of the two leads between *b* and *c*, making 14 volts to *c*; adding the drop of $2 \times 2 = 4$ volts between *c* and *d* makes the drop at the latter point 18 volts, and the drop at *e* becomes $18 + 2 \times 2 = 20$ volts.

The following tabulation will make the above calculation more plain. The C^2R, or the energy loss in watts, is added for after reference.

	a	b	c	d	e
C² R loss	0	16	9	4	1
Drop	0	4	3	2	1
Current	5	4	3	2	1
Resistance	0	1	1	1	1
Resistance	0	1	1	1	1
Current	5	4	3	2	1
Drop	0	4	3	2	1
C² R loss	0	16	9	4	1
Total drop	0	8	14	18	20
" C² R loss	0	32	50	58	60

Fig. 2 is a system of wiring used frequently for a circle of lights, as in a dome, and may be employed wherever a circuit completely girdles a space; in these cases the positive and negative leads start out from the feeder in opposite directions, and end dead near the starting point.

Referring to the figure, the drop for the lamp, *a*, is that of the negative lead alone, or $1 \times 1 + 2 \times 1 + 3 + 1 + 4 \times 1 = 10$ volts. For the lamp, *b*, the drop is $4 \times 1 = 4$ volts on the positive lead and $2 \times 1 + 3 \times 1 + 4 \times 1$ or 9 volts on the negative lead, making 13 in

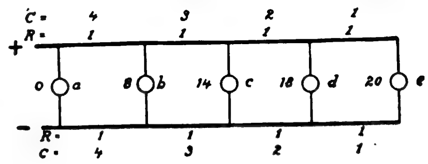


FIG. 1.—USUAL INCANDESCENT CIRCUIT.

all; similarly the drop for *c* is 9 volts on the positive and 7 on the negative or 14 in all; of *d*, 9 on the positive and 4 on the negative, or 13 in all; and for *e*, 10 on the positive lead alone. Tabulating as before, we have

	a	b	c	d	e
C² R loss	0	16	9	4	1
Drop	0	4	3	2	1
Current	5	4	3	2	1
Resistance	0	1	1	1	1
Resistance	0	1	1	1	1
Current	0	1	2	3	4
Drop	0	1	2	3	4
C² R loss	0	1	4	9	16
Total drop	10	13	14	13	10
" C² R loss		32	50	58	60

From the above it will be seen that the second method does not, as is sometimes

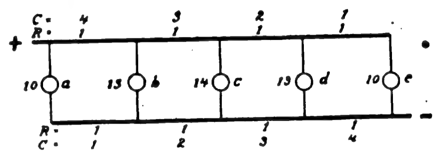


FIG. 2.—INCANDESCENT CIRCUIT WITH REVERSED CURRENTS.

thought, give a uniform drop. The maximum drop, however, is reduced from 20 to 14 volts, and the difference in drop from 20 to 4 volts; this latter is the point of practical importance, as the voltage of the feeder end

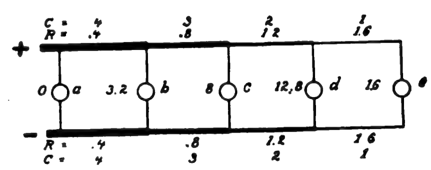


FIG. 3.—INCANDESCENT CIRCUIT WITH GRADUATED CONDUCTORS.

would include the ten volts, and therefore the reduction is actually from 20 to 4 volts. The same weight of wire is used in both cases, and the heating loss is the same.

Fig. 3 illustrates the case of leads in which

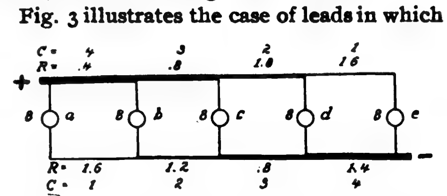


FIG. 4.—INCANDESCENT CIRCUIT WITH GRADUATED CONDUCTOR AND REVERSE CURRENT.

the density of current is the same everywhere throughout the circuit; that is, the wire carrying 2 amperes has one-half the cross section of the wire carrying 4 amperes, In order to be able to make direct comparison with the first two cases, the circuit as shown has the same weight of wire. As the currents are as 4 : 3 : 2 : 1 the resistance has been fixed inversely in the same proportion, or as .4 : .8 : 1.2 : 1.6, this giving the same weight of wire as in cases 1 and 2, and an equally density of current throughout the circuit.

Proceeding as before, the drop for the lamp, *a*, is zero; of lamp *b*, it is $.4 \times 4 + .4 \times 4 = 3.2$ volts; of lamp *c*, 3.2 volts $+ 3 \times .8 + 3 \times .8 = 8$ volts; of lamp *d*, 8 volts $+ 2 \times 1.2 + 2 \times 1.2 = 12.8$ volts; and of lamp *e*, 12.8 volts $+ 1 \times 1.6 + 1 \times 1.6$ volts $= 16$ volts. Tabulating we have

	a	b	c	d	e
C² R loss		6.4	7.2	4.8	1.6
Drop	0	1.6	2.4	2.4	1.6
Current	5	4	3	2	1
Resistance	0	.4	.8	1.2	1.6
Resistance	0	.4	.8	1.2	1.6
Current	5	4	3	2	1
Drop	0	1.6	2.4	2.4	1.6
C² R loss		6.4	7.2	4.8	1.6
Total drop	0	3.2	8	12.8	16
" C² R loss	0	12.8	27.2	36.8	40

In this case it will be seen that, with the same weight of wire, the total drop is 4 volts less than in the case of Fig. 1, and greater than in the case of Fig. 2. The heating loss, moreover, is only two-thirds as great as in the other two cases, being 40 watts instead of 60. The system therefore gives greater economy with less drop. By using 20 per cent. less copper, the drop would be brought up to that of case 1, and the heating loss would yet be 20 per cent. less.

Fig. 4 is the parallel of Fig. 2, but with an equal current density in each wire. The drop of the lamp, *a*, is the drop of the negative wire, or $1 \times 1.6 + 2 \times 1.2 + 3 \times .8 + 4 \times .4 = 8$ volts; the drop of *b* on the positive lead is $4 \times .4 = 1.6$, and on the negative lead, $2 \times 1.2 + 3 \times .8 + 4 \times .4 = 8$ volts. Similarly, the drop of *c*, *d* and *e* will be found 8 volts in each case, or the arrangement of Fig. 4 gives an equal drop for every lamp in circuit. The watt loss is the same as in case 3. Tabulating as before, we have

	a	b	c	d	e
C² R loss	6.4	7.2	4.8	1.6	
Drop	1.6	2.4	2.4	1.6	
Current	4	3	2	1	
Resistance	.4	.8	1.2	1.6	
Resistance	1.6	1.2	.8	.4	
Current	1	2	3	4	
Drop	1.6	1.2	2.4	1.6	
C² R loss	1.6	4.8	7.2	6.4	
Total drop	8	8	8	8	
" C² R loss	8	20	32	40	

While the final case is the ideal one, it can rarely, if ever, be realized in practice. Case 3, on the other hand, can sometimes be applied, and in a following article, the calculation of a practical example will be given.

Conductivity of Aluminum.

In a recent paper read before the Franklin Institute, Mr. Joseph H. Richards and John A. Thomson examine the various results arrived at by themselves and others as to the conductivity of aluminum, and give the following conclusions: The conductivity of pure aluminum is probably 66 per cent. of that of copper; when 98.5 per cent. pure, the conductivity is 55 per cent. which becomes 59, 61 and 63 per cent. when the aluminum is 99, 99.5 and 99.75 per cent. pure.

Letters on Practical Subjects

Freaks of Lightning.

To the Editor of American Electrician:

I happened to be in a station one day last summer when a heavy thunder-storm was going on. The station in question runs both an electric railway and incandescent lights, and it is customary to shut down the machines during a storm, the circuit breakers, feeder and dynamo switches being opened, but the generators left running. On the occasion referred to a flash of lightning burned out both generators simultaneously. Perhaps some of your readers can explain how the generators burned out, there having been no connection whatever with the lines.

Wabash, Ind. C. H. LATTA.

Sectorless Wimshurst Machines.

To the Editor of American Electrician:

In the February number, in answer to a query, I notice you severely condemn the sectorless Wimshurst machine. I have constructed several Wimshurst machines with and without sectors, and much prefer the latter for the following reasons: The spark is longer and much more intense; the machines are easier to construct, and can be readily cleaned; they will work in any weather in which one with sectors will. I have just built a 12-plate 32-in. diameter sectorless machine, and its efficiency will convince anyone that sectors are detrimental.

Eloise, Mich. S. M KEENAN.

Alternators in Parallel.

To the Editor of American Electrician:

I have been considerably interested by the different letters relative to the paralleling of alternators, which have appeared in the issues of March and April. I agree with Mr. Paul M. Lincoln that the "useful" output of alternators in parallel depends upon their relative speeds. The causes of differences in the form of wave, however, may also cause differences in the armature reaction of each machine, and if the load varies, the field excitation can hardly be adjusted accurately and rapidly enough to prevent synchronizing or cross currents. These currents may, perhaps, not be properly called a part of the output, but their heating effect may, and generally will, cause serious inconvenience.

If the alternators have approximately the same armature reaction and regulation, or if they will carry the same loads with the same corresponding voltage, the best way to run them is as follows: First find the amount of field excitation necessary, at different loads, to give the required voltage. This being determined for each machine, avoidance of cross currents with either steady or variable loads can be obtained by properly exciting each machine. To regulate the division of load, or useful output, adjust the speeds so that neither machine will drag upon the other. That is, in order to even the loads, so adjust the governor of the driving source of the most lightly loaded machine that the tendency will be to slightly increase the speed.

In an article by the writer, in the March issue of the AMERICAN ELECTRICIAN, on page 84, columns 2 and 3, from paragraph 5, the above is tersely spoken of, and the difference between the running of alternators driven from the same shaft by belts and those driven from separate sources, is discussed.

The statement is made that alternators so arranged that their speeds cannot be separately adjusted, will not run well in parallel, and that no amount of field regulation will overcome the difference in currents.

Norwich, Conn. H. E. RAYMOND.

A Home-Made Storage Battery.

To the Editor of American Electrician:

Having great need of an accumulator for experimental and practical work, I procured an old 23-plate section, divided and mounted it in three rubber cells. The positive plates were repasted, using a stiff paste of red lead and sulphuric acid—one part commercial acid to two parts water. The paste may at first assume a dark reddish brown color, when more acid must be added until all appearance of red lead is gone. About twenty-four hours' drying in a moderate temperature is sufficient. In mounting I used two shallow combs for feet, and by inserting a few ebonite forks between the plates, made a very compact, rigid and symmetrical section. The electrolyte should have a specific gravity of about 1.180. The cells are durable, present a nice appearance and cost not more than $1.20 apiece.

Wilmington, Del. H. L. GOODING.

Commutator Troubles.

To the Editor of American Electrician:

Mr. H. S. Hall's letter in your April issue is valuable to two classes of men—those who electrically know very little and those who know too much; to the first, it is a practical and forcible indication of the most important stimulant to armature longevity, namely, care of commutators and brushes, and to the second class is an equally forcible reminder that some sources of trouble are so commonplace that we are apt to overlook them.

Most of the troubles inherent to dynamo electric machines, and especially to street railway motors, can claim the brushes or commutator as their origin, and here the writer wishes to add that worn commutators and the thinning of bars consequent thereto, are not the only source of the brushes losing their setting. Wherever wooden yokes are used to hold or insulate brush holders, this trouble and even worse ones can be looked for in course of time, because the heat in a closed motor will eventually shrink the wood, and either draw the brushes together or loosen the fastenings so that the brush holders themselves become shaky. The immediate result is vicious sparking, and finally the current jumps over to the motor frame.

The reason that the current jumps is, that upon sudden increase of current the arcing, due to the loose brush leaving the commutator, vaporizes the carbon and copper, and this hot vapor offers to the current an earth path of less resistance than the natural path which includes the motor's self-inductance.

Where a series-parallel controller is used, this jumping over to frame almost invariably takes place when the controller handle passes from series to parallel, because it is at this point of sudden transition that not only is the current a maximum, but so is the inductive resistance of the motor circuit. The truth of this statement is evidenced by the fact that roads using ordinary multiple controllers or rheostats are comparatively free from "jumping over" troubles.

Louisville, Ky. L. B. MCCLELLAN.

Polarity Test of a Dynamo.

To the Editor of American Electrician:

Some months ago, the writer, while out on road work, was somewhat surprised when a friend, the manager of a street railway, imparted the information that he was using a generator that always reversed its polarity when its field circuit was opened; *i.e.*, the field polarity due to residual magnetism was opposite to that existing when the dynamo generated a field current.

Mr. ——— made a test in the writer's presence, and the test, as it was conducted, sustained his remarkable statement. With the field self-excited, the right hand upper pole attracted the north end of the field current, but upon removing the field current, the compass needle promptly swung around and presented its south end to the pole-piece.

In face of the facts that the machine was an isolated one, and that the field current was in each case very gradually removed, the behavior of the compass seemed to be inexplicable; but the explanation of the very unusual action finally resolved itself as follows:

The compass was held so near the armature head that under field excitation it indicated, not the polarity of the pole-pieces itself, but that of the pole induced in the armature core by the field's magnetic lines of force. Upon removing the exciting current, the armature core, being of soft iron, retained very little residual magnetism, but the cast iron field core and pole-piece retained enough to direct the magnet of the compass. Upon shifting the compass to a position nearer the pole-piece, the polarity of the deflection remained the same whether the field current was on or off.

It must be borne in mind that the polarity of an induced pole is the reverse of that which induces it; so that the lesson to be learned from this bit of experience, is that when testing the polarity of an excited dynamo, hold the compass well over on the pole-piece side of the air gap.

Pittsburgh, Pa. E. THOMAS.

ELECTRICAL CATECHISM

121. For what purposes are two-phase currents used?

Two-phase currents may be used for lighting incandescent or arc lamps, either as two independent currents or as in conjunction. For operating motors, both currents are used in each motor, the two being necessary for obtaining the rotating magnetic field which is desirable for self-starting alternating-current motors.

122. Is it necessary to have four wires for carrying two phase currents?

Four wires are generally used, two for each circuit, as suggested in Fig. 1, in which,

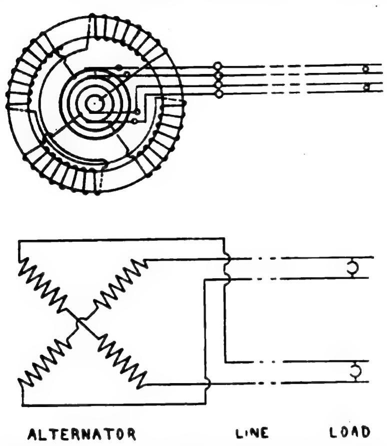


FIG. 1.—FOUR-WIRE TWO-PHASE CIRCUIT.

for simplicity, the transformers are omitted. It is practicable, however, to use one wire for each circuit and a common wire for the

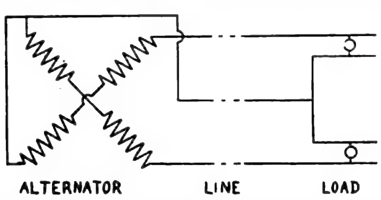


FIG. 2.—THREE-WIRE TWO-PHASE CIRCUIT.

two, as suggested in Fig. 2, similar to the three-wire direct-current system.

123. In the three-wire two-phase system, is the common wire the same size as the others?

In order to give the same loss on the line, the common wire should be 1.414 times larger than the other wires, because the current in the common wire is the resultant of the two currents in the other wires.

124. Is not the current in the common wire equal to the sum of the two currents?

Yes and no. At any instant the current in the common wire equals the sum of the two currents. But an ammeter in the common wire would not indicate as much as the sum of the ammeter readings in the two circuits. For instance, if each circuit was carrying 10 amperes, the common wire would be carrying 14.14 amperes.

125. Do not the rules of ordinary arithmetic apply to alternating currents?

They do when rightly applied. Ordinarily, 10 + 10 = 20, but in this case, 10 + 10 = 14.14. The same thing is true in many other cases with alternating currents. The difficulty is caused by the fact that the two currents or E. M. Fs. may have a difference of phase, so that they do not reach corresponding values at the same time. At any particular instant, the current in the common wire is the sum of the two currents at that same instant. But the ammeter does not measure the instantaneous values of the current, it measures the effective current. If the two currents were in the same phase, reaching corresponding maximum values at the same time, the resultant current in the common wire, as measured by the ammeter, would be equal to the sum of the two currents and, in the above example, the ammeter would show 20 amperes in the common wire. On the other hand, if the two currents were 180 degs. apart, one reaching its maximum positive value at the instant when the other reached its maximum negative value, the two currents in the common wire would exactly neutralize one another, and the ammeter would stand at zero. In this case the two circuits would be practically in series, the current being the same on each side, and the voltage between the two outside wires being double that between either outside wire and the neutral wire.

The way in which the two currents are combined in the common wire to form a resultant less than their sum is illustrated

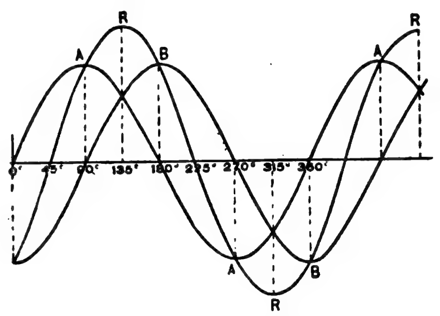


FIG. 3.—COMBINATION OF TWO ALTERNATING CURRENTS.

in Fig. 3. Suppose that the sine curve, *A*, represents the current coming into the common wire from one circuit, while *B* represents the other current. The value of the resultant current, *R*, is found at any instant by adding the values of *A* and *B* at that instant. For example, at the instant marked 45 degs. the value of *B* is negative and exactly equal to the value of *A* at the same instant, so that the instantaneous sum or the resultant of the two is zero. Again at the point marked 90 degs., *B* is at zero, while *A* is at its positive maximum valve, and the sum equals *A*. A little later, at the point marked 135 degs., both *B* and *A* are positive and the resultant equals their sum at that instant. By following this analysis through the cycle, it is seen that the curve representing the resultant or sum of the simultaneous values is a curve similar to the others and its mean value bears the same ratio to its maximum value that the mean value of either of the component curves does to its maximum.

126. How are two-phase alternator armatures wound?

The two circuits may be entirely distinct, each having two collecting rings as suggested in Fig. 1. Or the two circuits may be coupled at a common middle point as suggested in Fig. 4, each circuit having two

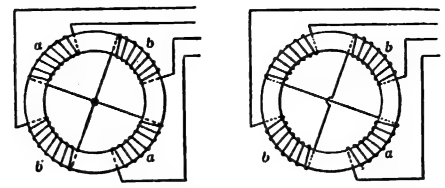


FIG. 4.—TWO-PHASE ALTERNATOR ARMATURE WINDINGS.

collecting rings. Or the two circuits may be coupled in the armature so that only three collecting rings are required, as suggested in Fig. 5.

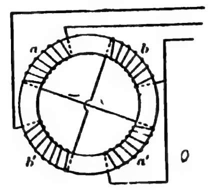


FIG. 5.—TWO-PHASE ALTERNATOR ARMATURE WINDING.

127. How are three-phase alternator armatures wound?

There are generally three coils or sets of coils, 120 electrical degs. apart as in the ideal sketch in Fig. 6. Instead of having two terminals for each coil or circuit, these are generally connected so that only three

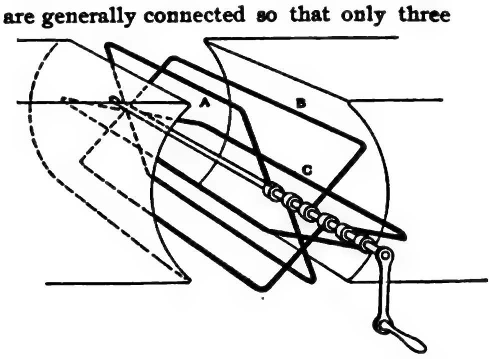


FIG. 6.—THREE-PHASE ALTERNATOR ARMATURE WINDING.

or four collecting rings are required. When connected so that the three coils form a complete circuit within themselves as indicated in Fig. 7, it is said to be a mesh or triangle winding. When the three coils are connected at a common central point as indicated in Fig. 8, it is called a star or Y

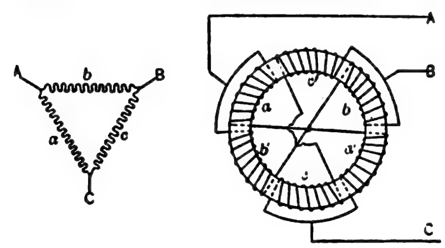


FIG. 7.—THREE-PHASE ALTERNATOR ARMATURE WINDING.

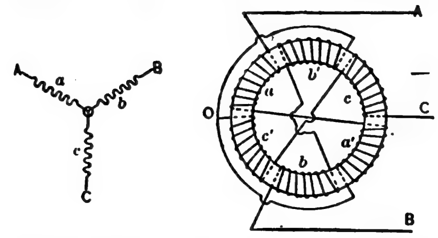


FIG. 8.—THREE-PHASE ALTERNATOR ARMATURE WINDING.

winding. Three-phase alternators usually have three collecting rings, although there may be a fourth ring connecting with the common center of the star winding.

QUERIES AND ANSWERS

Why do Foucault losses in a dynamo vary as the square of the speed? O. F. L.

Because the Foucault or eddy currents vary as the speed and therefore the C^2R loss varies as the square of the speed.

How can I build a small direct-current dynamo to run 2 or 3 16-CP lamps, and what power will be required to run it? T. N.

The motors whose construction is described in the February and April numbers will, when run as dynamos, light two lamps. About one-quar er horse power will be required.

How can I locate a ground on an incandescent line outside of the station? I find the line to be clear from trees, etc. A. G. W.

The ground is most probably on house wiring. In the case of a small plant the practicable way of locating it is by disconnecting the main fuses and testing the various house circuits.

I wish to connect the field safety device shown on p. 27, January issue, to an arc machine. Would it be better to connect it at the machine or the switchboard, and is it necessary to have a fuse in circuit? F. Y.

It should be connected at the dynamo between the two field terminals. A fuse should be in circuit, as it is possible for the device to become short-circuited.

Why are high-tension continuous current sconsidered unsuitable for long-distance transmission work? O. F. L.

Unlike in the alternating system, the insulation of the generator and receiver must withstand the entire voltage; the commutator at high voltages is apt to be troublesome; the danger from the high voltage is everywhere present; every fitting must be insulated for the voltage used and the system is not as flexible as the alternating one. Nevertheless, some European engineers of high authority favor the direct over the alternating current for long-distance transmission.

1°. Why are telephone lines transposed at short distances? 2°. What conditions determine the capacity of a line? O. F. L.

1°. To protect the line from external inductive effects, such as from other telephone lines, terrestrial magnetic disturbances and electric light lines. The lines of force will cut in or out two adjacent loops in reverse direction, thus neutralizing the inductive E. M. F. 2°. The distance apart of the two parts of the condenser formed, and the specific inductive capacity of the separating dielectric. In the case of aerial lines the former factor is the distance from the earth and the latter is unity. In concentric conductors the factors are the thickness of the insulation and its specific inductive capacity.

How can the original color be restored to hard rubber which has become discolored? J. P.

We are informed by one manufacturer that it is necessary to work over the entire surface, either by turning or with sandpaper or pumice stone, and then repolish with rotten stone and oil. Another manufacturer writes that the color can be restored to hard rubber by treating it with bisulphide of carbon. The rubber may be dipped for a second or two, or it may be rubbed with a piece of cotton saturated with the liquid. Too much of the liquid should not be used, as it will soften the rubber. To obtain the best polish it is necessary to use polishing buffs, but in the absence of these a fair polish may be obtained by using a dry piece of flannel and rubbing vigorously.

I have a 110-volt fan motor which I would like to run from a battery. How can its voltage be reduced? G. H. S.—A. M. D.

Both field and armature will have to be rewound. Reduce the number of wires on the armature in about the same proportion that the voltage is reduced, using wire of a proportionately larger size. Reduce the number of turns on the field in the same proportions, using a correspondingly larger wire. In other words, the field should have the same number of ampere-turns, and the armature less wires in the proportion of the lower to the original voltage.

1°. What voltage and amperage are used for electrocution? 2°. Has Mr. Tesla taken 250,000 volts through his body? C. J. R.

1°. In New York State a voltage of 1740 has been used, which caused a current of 8 amperes to flow, producing instantaneous death. Currents, not volts, pass through a body. Aside from the shock at contact, voltage has an effect only through the current which it causes to flow through the body; the value of this current also depends upon the resistance encountered, which varyies in different bodies, and with the state of the skin as to dryness and its thickness. 2°. Mr. Tesla has subjected himself to the voltage stated, but from a circuit having a frequency of several hundred thousand periods per second. For some reason not known, at very high frequencies, the body may be subjected to enormous voltages without danger.

In February queries a storage cell described is said to have 4 or 5 ampere-hours per pound of plate. Does this refer to both plates, or only the positive? What are the charging and discharging rates of a storage battery? S. T. L.

To the positive plates alone. A better rule is a discharging current of 7 amperes per square foot of positive surface, counting both sides of the plate, and 35 ampere-hours per square foot of same surface. These figures refer to normal rates; if the discharging rate is made 10 amperes, the capacity becomes 30 A-H; if made 5 amperes the capacity is increased to 40 A-H. The discharging rate of 10 amperes should not be exceeded with pasted plates. The "boiling" of the electrolyte fixes the charging rate; that is, if the absorbing capacity of the plate is exceeded, the excess of current is wasted in separating the electrolyte into its component gases, the escape of which causes the electrolyte to have the appearance of boiling. As the charging proceeds, the current has to be decreased to avoid "boiling."

How can a ground be located on an arc circuit when the lights are burning, using a bank of incandescent lamps? W. E. T.

The accompanying diagram shows the arrangement when a double bank is used. The levers are connected to a good ground, and as many 100-volt incandescent lamps used on each side as there are arc lamps. By moving the two levers to such a point that the lighted parts of both banks of lamps glow equally, the ground will be between the arcs corresponding to the two incandescents on which the levers respectively rest. A single bank may also be used, and the two arc machine terminals alternately switched on, in which case it will be better to use 50-volt lamps, owing to the greater difficulty in making the comparison. Referring to the double bank, if for example, the ground is between arc lamps 3 and 4 and has a resistance of one 100-volt incandescent lamp (200 ohms), when the left hand lever is at 4, the other will be at 3; or if the former is at 5, the latter will be at 2.

1°. As practically all the lines of force passing from a dynamo pole-piece to a toothed armature core pass through the teeth, how do the conductors in between the teeth and not cut by lines of force, generate? 2°. Why is a toothed-armature machine more efficient than a smooth-core machine, when the air-gap, iron to iron, is the same? BUTTE.

1°. Assuming physical lines of force for convenience, it is obvious that the lines passing into a certain tooth when that tooth is opposite the center of the pole-piece, cannot remain there when the tooth is opposite the edge of the pole; in shifting backwards from tooth to tooth as the teeth pass along, the lines are conceived to pass across the wires between the teeth. The action is really similar, however, to that found in a transformer having a closed magnetic circuit. 2°. It is not always more efficient, but works more smoothly, developing no eddy currents in the conductors and requiring no adjustment of brushes for changes of load. Very few, if any, toothed-armature machines are built with an all-air gap equal to what would be required for the same size machines with smooth-core armatures.

What is a wattless current? O. F. L.

In an alternating-current circuit that portion of the current which is not effective in doing work is called the "wattless" current. An analogy is the "horse-powerless" pressure exerted on a piston when it is on a dead center. As an example, suppose an alternating current lags one-sixth alternation (30 degs.) behind the E. M. F.; that is, when the E. M. F., is at a maximum the current has not yet reached its maximum. It is evident that as the product of the effective volts and amperes corresponds to the two being in phase, their product in the case mentioned will not give the true watts, the latter being made less by the lag. If the volts and amperes measured are each 50, the apparent watts are 2500; the current effective in producing work, or the component in phase with the E. M. F. will be 43 amperes (cos. 30 degs. $\times$ C), and the wattless current 25 amperes (sin 30 degs $\times$ C), the latter being the component always at "dead centers" with the E. M. F.; the true watts will, therefore, be $50 \times 43 = 2250$ instead of 2500; the power factor is the quotient of the former by the latter, or .9. That is to say, the actual current in the line may be considered as made up of two currents, one of 43 amperes in phase with the E. M. F., and another of 25 amperes lagging one-half alternation, the latter not having any capacity for work. If the original current and E. M. F. lagged one-half alternation, the entire current of 50 amperes would be wattless. If will be seen that the sum of the two currents is not an arithmetical one, being what is called the "vector sum," or the square root of the sum of the squares.

New Apparatus and Appliances.

PORTABLE VOLTMETER.

The type of portable voltmeter illustrated in the accompanying cut is stated by the makers to be the result of a large number of experiments covering several years, followed by time tests in actual practice. In its construction nothing is incorporated which is subject to change or deterioration and the instruments are calibrated from absolute standards of voltage. The system is such that there is no magnetic lag nor any error due to self-induction, and therefore the instruments are equally applicable to alternating and direct currents.

The instruments are mounted in highly polished mahogany cases with key lock and leather carrying handle. With each instrument is included a pair of flexible leads, for which a special compartment is provided. Two features are incorporated which the makers believe busy users will appreciate; one is that the instruments are dead-beat without the use of a mechanical brake, and

PORTABLE VOLTMETER.

the second that each voltmeter is provided with a switch for reversing the direction of the current flow when used on direct-current circuits. This latter enables the user to obtain mean readings easily and promptly and, further, by turning the switch to the dead-point, to throw the instrument out of circuit without disconnecting leads.

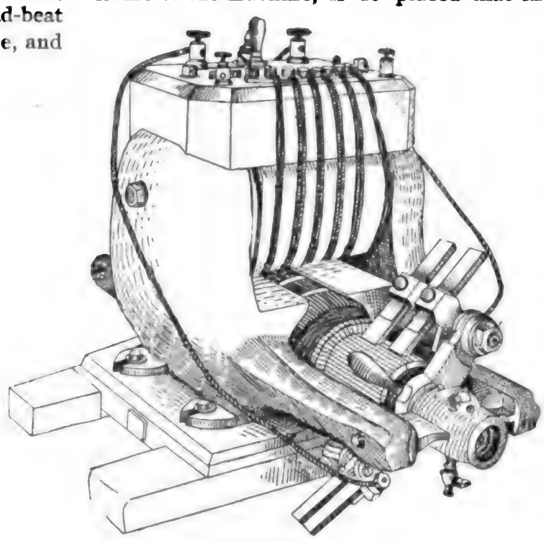
These voltmeters are made in ranges from 12 to 700 volts, single and double scales, so that all classes of testing work are provided for. The manufacturers are the Keystone Electrical Instrument Company, North Street and Montgomery Avenue, Philadelphia.

POLK SAFETY MOTOR.

The motor illustrated in the accompanying illustration is claimed to have several new and valuable features, among which is a magnetic cut-off that avoids overloading and prevents burning out.

Coils of copper wire on separate spools are placed over the field, and by cutting out these coils with the switch lever, the same as in a rheostat, the density of the magnetic field is increased. When starting the motor the strength of the field varies from 3000 to 7000 ampere-turns, according to the size of the motor, which permits it to start under a heavier load than where rheostats are used. These same coils, after being cut out of the armature circuit, still remain as a part of the shunt fields; therefore every foot of wire is constantly in use.

All connections to the different coils are made on the cap, which is of wood or slate, thus permitting easy access to the connections. In case of accident to one of the rheostat coils, a jumper cutting out the damaged coil can be put on in a few minutes, and the motor run as usual, until such time as repairs can be made. A magnetic detent, controlled by the magnetism of the frame of the machine, is so placed that in



SAFETY MOTOR.

case the field circuit should, from any cause, be opened, the current cannot be turned into the armature and the machine burned out, as is often the case where rheostats are used.

The frame of the machine is simplified so that the armature can be removed by taking out two bolts, and all the field coils removed by taking out four bolts. These machines, which have been in use over a year and given entire satisfaction, are made by the Electric Novelty Works, Atlanta, Ga.

LIGHTNING ARRESTERS.

The Wirt alternating-current short-gap arresters shown herewith, have been especially designed to operate effectively with very small gap spaces. The arrester for 1000-volt circuits has but one spark gap of $\frac{1}{16}$ in. between two metal cylinders 2 ins. in diameter and 2 ins. long. One cylinder is connected to the overhead line and the other to the ground, and a low, non-inductive graphite resistance is placed in circuit. The combined action of the metal cylinders and non-inductive resistance prevents the heating of the cylinders when the lightning discharge passes across the gap, and from making the gas which would enable the alternator to maintain the arc. The arc itself is extinguished by the reversal of the alternator current. This arrester is, therefore, not an arc-rupturing device, but actually prevents the formation of an arc, the action being dependent upon the cooling effect of the large metal cylinders, which effect is increased by the introduction of a non-inductive resistance, and not upon any non-arcing property of the metal itself.

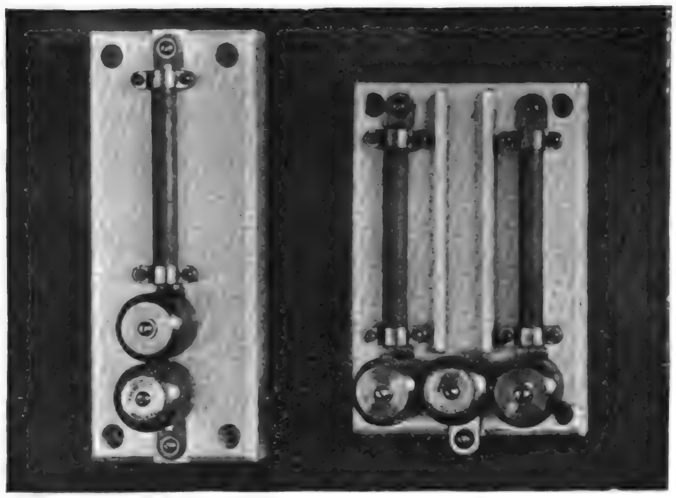


FIG. 1.—WIRT ALTERNATING-CURRENT SHORT-GAP LIGHTNING ARRESTER.

The arrester for 2000-volt work has two gaps of approximately $\frac{1}{32}$ in. each and a low non-inductive resistance. This arrester will not hold a short circuit when connected directly across a 2400-volt alternating-current line, but will hold an arc when tested on a 500-volt continuous-current line. This proves clearly that the reversal of the alternating current itself extinguishes the arc.

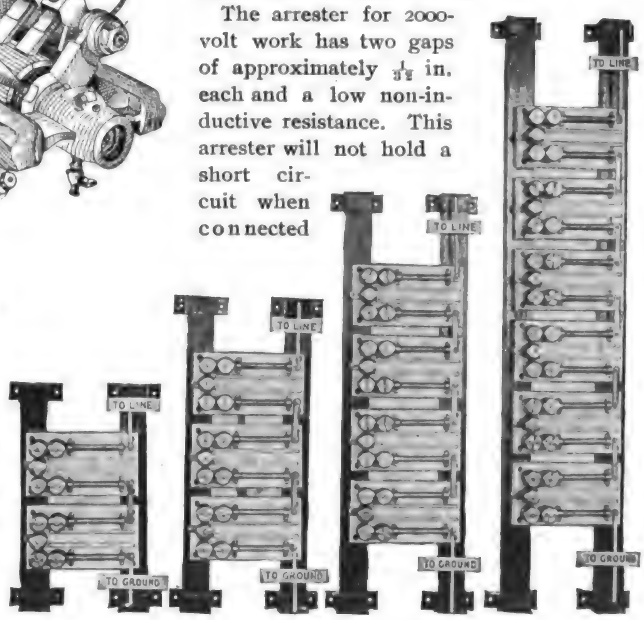


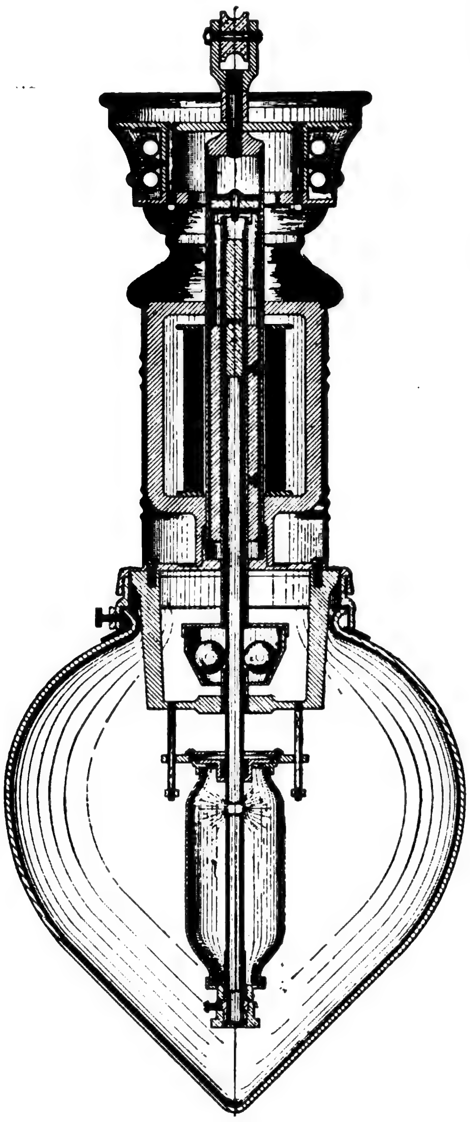
FIG. 2.—GROUP OF WIRT ARRESTERS.

The Wirt arresters are designed for use on alternating-current circuits at practically any potential, the standard list including an arrester for 15,000-volt lines. For circuits above 2000 volts the standard 2000-volt double-pole arrester has been adopted as a

unit, several of these being connected in series for high-potential work.

Arresters of this type have been adopted for the protection of the power line connecting Niagara Falls and Buffalo, at the power house of the Niagara Falls Power Company. An exhaustive test was recently made to determine the proper number of gaps and resistance for an 11,000-volt, 5000-HP line. The arrester under normal action only showed a small arc about as large as a pin head between the cylinders. After many successful tests, the proper number of gap spaces was ascertained to be fourteen, with a wide margin of safety. The gap spaces are each $\frac{1}{32}$ in.

Arresters of this type are now standard with the General Electric Company, for all alternating-current work, and a large number are already in service protecting long-distance transmission power lines, having a working voltage as high as 15,000 volts.



ENCLOSED ARC LAMP.

ENCLOSED ARC LAMP.

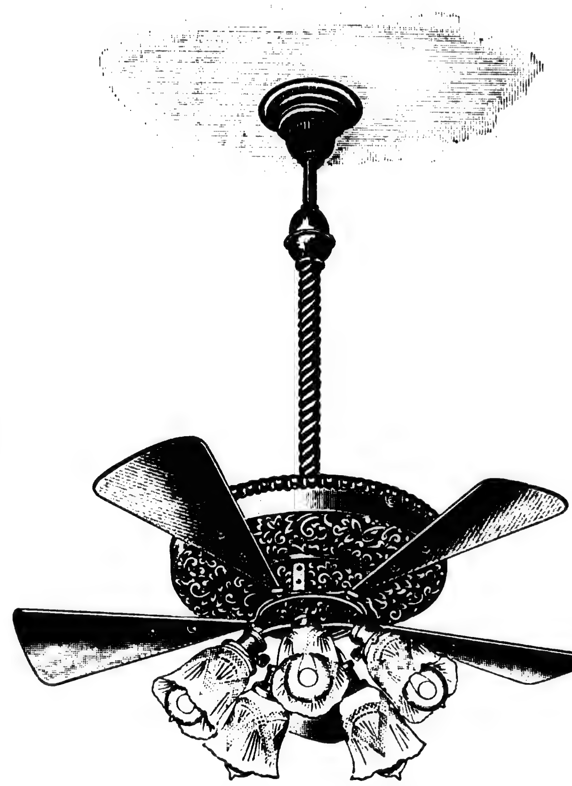
The enclosed arc lamp illustrated herewith, is stated by the makers to be the final outcome of experiments first begun many years ago, and which as early as 1884 resulted in a lamp that was successfully burned for 100 hours, using the ordinary ½ in. × 12 in. carbons, the trial having been made on the steamer "Bostana."

In the present form of the lamp, particular attention has been paid to all electrical and mechanical details. There are no rods, chimney, clock-work, gearwheels, springs or side-rods. The arc is entirely inclosed by the inner globe, which is in turn surrounded by the outer globe, preventing the access of fresh air, thus prolonging the life of the carbons to from 125 to 150 hours. The carbon is gripped directly without the intervention of any carbon rod; the clutch is composed of four porcelain balls, maintained in position by a retaining receptacle and performing all the functions of a ball-bearing, arc-maintaining device. It is impossible for the carbon to slip except at the proper time when feeding takes place.

The lamp is ornamental in appearance for both interior and exterior service. The outdoor lamp is weather-proof, preventing any moisture from getting into the mechanism. The lamps are furnished to consume 4 amperes, 4½ amperes and 5 amperes at 80 volts across the arc, with 110 volts on the line.

The general arrangement of this lamp is such that it is extremely easy for even an inexperienced person to re-carbon and take care care of it. Owing to the manner in which the inner globe is held in position, there is ample room for the glass to expand and contract without danger of breaking, and the breakage of inner globes is rare. The outer globe is supported by a ring at its top, which when lowered, is held by three chains in such a manner that the globe can be raised or lowered without detaching it.

The Nowotny Electric Company, Cincinnati, O., manufactures the above lamp in types for both interior and outdoor use.



INDUCTION FAN MOTOR.

INDUCTION CEILING FAN.

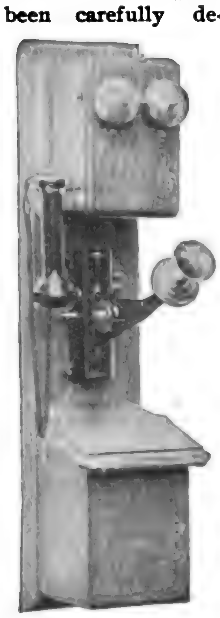
The motor actuating the fan shown in the accompanying illustration is of the induction type for single phase alternating currents, and has no moving wire, commutator or brushes. The design is that of a "wheel within a wheel," the outside wheel (the field) being stationary, while the inside wheel (the armature) revolves on a large solid shaft on a ball-bearing, immersed in a cup of oil. The framework of the ornamental portion above the fans is the field of the motor, and has been designed to give an artistic appearance without the aid of finishings not entering into the structure.

The fan blades are of aluminum and revolve at from 150 to 210 revolutions per minute. The finish is a combination of polished and dead surfaces, suited to the different parts of the design. The canopies and tubing which form the hanger are polished; the top of the motor proper is black enamel; the outside band is polished, while the carved design on the bottom of the motor is satin finish, interspersed with polished rings, and finished with a polished canopy over the switch at the bottom of the motor. The light fixture is for from two to five lights.

The above electric fan is made by the Emerson Electric Manufacturing Company, St. Louis, Mo.

ADJUSTABLE ARM TELEPHONE.

The telephone shown in the accompanying illustration is especially designed for long distance service. The transmitter is attached to an arm admitting of the nicest adjustment, and all of the parts have been carefully designed for the highest class of service. The transmitter is a Swedish microphone of the well-known Ericsson type, in which coal grains are used as the microphonic material. These grains do not pack and therefore no provision for adjustment is necessary and none is made. The makers claim that a microphone of this type can be immersed in water for a month without being impaired, while its efficiency is absolutely independent of weather conditions.

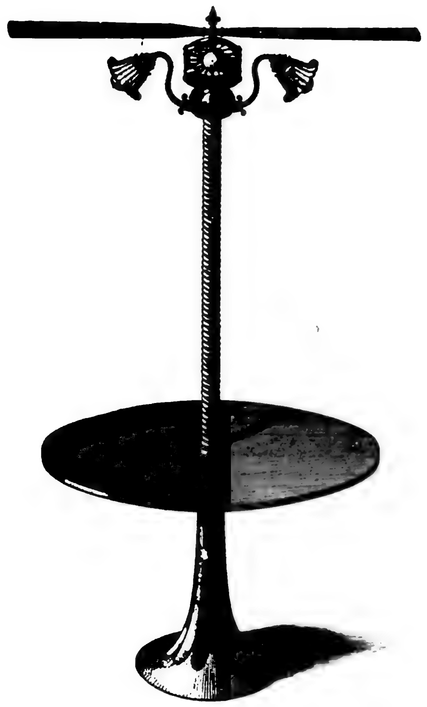


ADJUSTABLE ARM TELEPHONE.

The American agents for the Ericsson microphone are Whitman & Couch, 196 Summer Street, Boston.

COLUMN FAN.

The column electric fan shown in the accompaning cut is arranged for either two or four fan blades, and is fitted with a regu-



COLUMN ELECTRIC FAN.

lating switch which gives it two speeds, namely, 75 and 150 r. p. m. The motor is designed for direct-current, constant-potential circuits of 110, 220 and 550 volts. The bearings of the motor are self-oiling, the brushes are of carbon, and the motor operates noiselessly. The general finish of the column fan is polished brass, though other finishes are supplied. The feature of a circular table fitting around the standard of the fan is new, and will, without doubt, be appreciated. The fans are furnished without light or table, or brackets for lamps and tables added, as required.

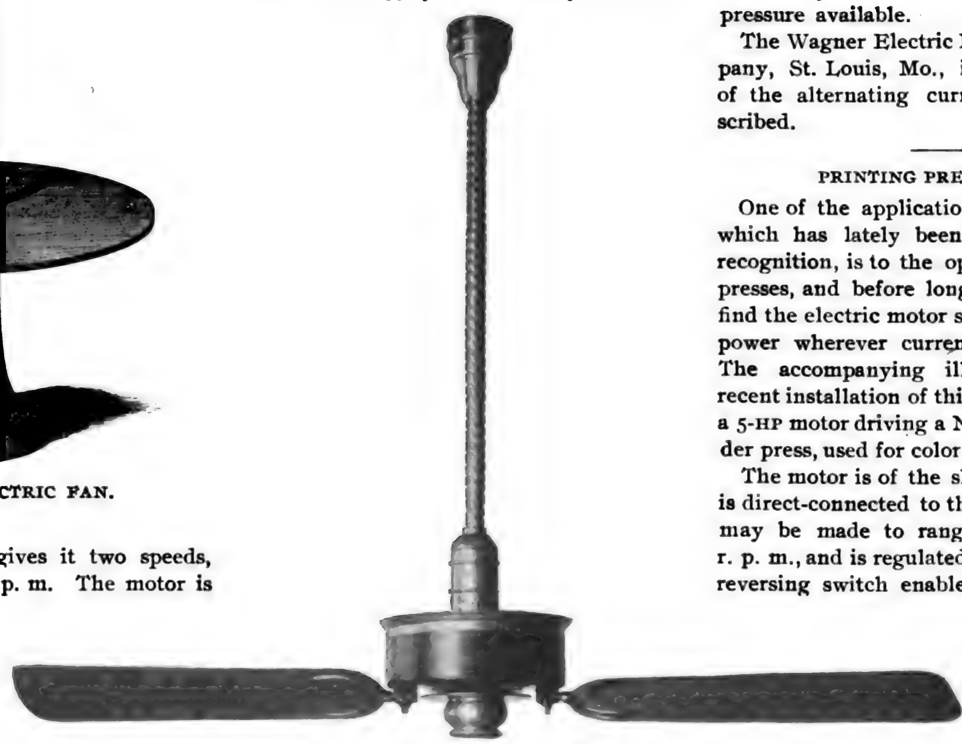
The column fan illustrated is made by the Western Electric Company, of Chicago and New York.

SINGLE-PHASE FAN MOTOR.

The motor illustrated herewith is of the induction type, without commutator, collector rings or brushes. The primary or field winding, which constitutes the stationary element, is a single circular coil having a self-inductance so high as to absolutely obviate any possibility of burning out, whether the motor is running or still. The secondary or armature winding—the movable element—is of the "squirrel cage" type, the construction being such that electrical injury is an impossibility.

The driving force being direct-acting on the main shaft, the complication of noisy, troublesome speed-reduction devices is at once done away with, and an extremely simple general mechanical construction follows. The entire frictional load is carried on an end ball bearing which runs in a cup of oil. So perfect is this method of suspension and lubrication that frictional resistance within the motor is practically negligible. A single filling of the oil reservoir to the level indicated is sufficient for one year.

These motors are made for two frequencies—60 cycles (7200 alternations) per minute, and 133 cycles (16,000 alternations) per minute. On either frequency of current two speeds are possible. The 60-cycle motor may be run at 125 r. p. m. with an energy consumption of 125 watts, or at 90 r. p. m. with an energy consumption of 90 watts. The 133-cycle motor may be run at



SINGLE PHASE INDUCTION FAN MOTOR.

speeds of 160 or 175 r. p. m. with an energy consumption of 90 or 125 watts. Regulation of speed is effected on a plug switch-board mounted on the top plate of the motor body. With a line voltage of 110 and the plug inserted in one of four holes, or with a line voltage of 55 and the plug inserted in a second hole, the lower speeds on either frequency are secured. With a line voltage of 110 or 55 and the plug inserted in one of two other holes, the higher speeds are secured. It will be seen that any motor, either for 60 or 133 cycles, may be run on either 55 or 110 volts nominal. This interchangeability is a great advantage, and will be especially appreciated by those who have had to carry a useless equipment of motors simply because they were not adaptable to the line pressure available.

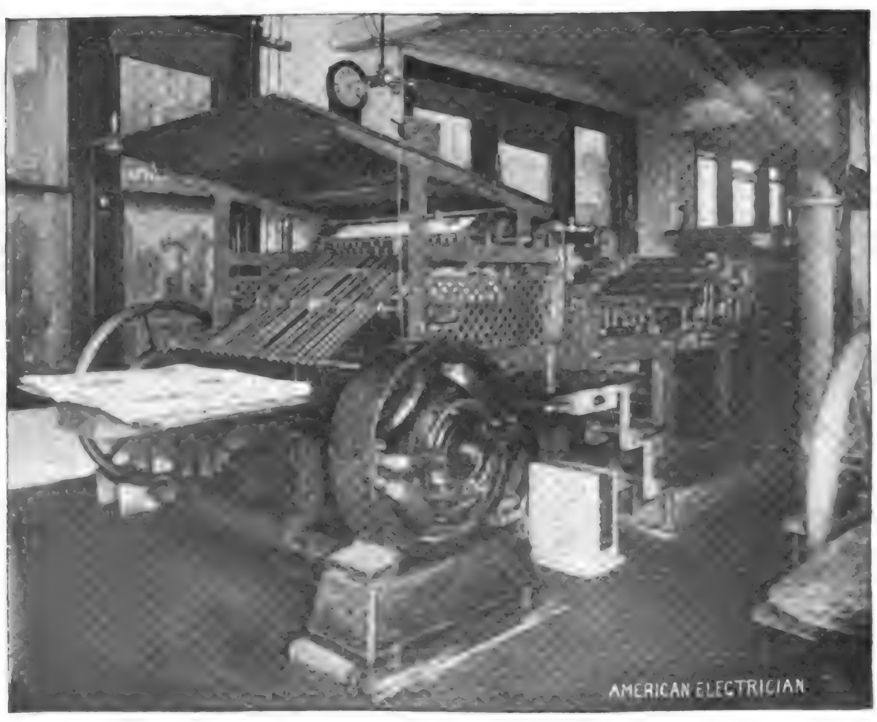
The Wagner Electric Manufacturing Company, St. Louis, Mo., is the manufacturer of the alternating current fan above described.

PRINTING PRESS MOTOR.

One of the applications of electric power which has lately been rapidly receiving recognition, is to the operation of printing presses, and before long we may expect to find the electric motor substituted for steam power wherever current can be obtained. The accompanying illustration shows a recent installation of this kind, consisting of a 5-HP motor driving a No. 7 Hoe stop-cylinder press, used for color and fine book work.

The motor is of the slow-speed type, and is direct-connected to the press. The speed may be made to range from 108 to 168 r. p. m., and is regulated by a controller. A reversing switch enables the speed to be reversed, and an electric brake can be instantly applied in case a sudden stoppage is necessary.

The above motor is one of several supplied, together with a complete electrical generating equipment, to the U. B. Publishing House, of Dayton, O., by the Thresher Electric Company, of the same city.



DIRECT-CONNECTED PRINTING PRESS MOTOR.

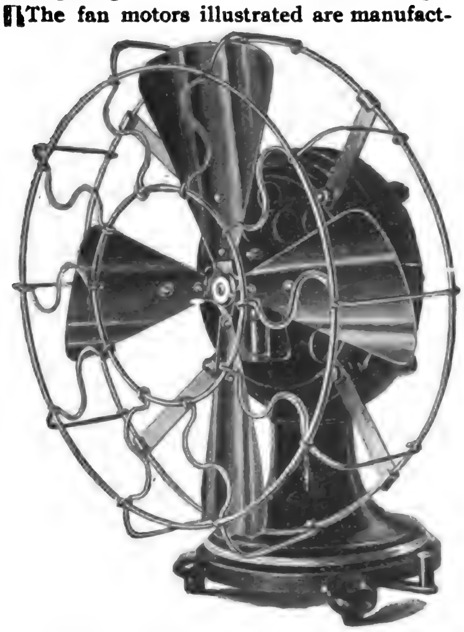
LUNDELL FAN MOTORS.

From among the many types of 1897 model Lundell fan motors we select two for illustration, an alternating-current desk motor and an electrolier outfit. The former motor is made to run with currents of 7200, 14,000 or 16,000 alternations per minute, and has three speeds—1200, 1400 and 1600 r. p. m.—fixed by the position of the starting and regulating switch, shown at the base. It is made for 52 and 104-volt circuits, taking 2.2 amperes at the former and 1 ampere at the latter—the energy thus being equivalent to that necessary for only two 16-CP lamps. The motor is handsomely finished in rich black japanning with gilt striping; the fan guards and all outside brass fittings are of polished brass or nickel plated.

The ceiling electrolier fan illustrated is made for direct currents of 110, 230 or 250 volts. At 110 volts .95 ampere is required for the motor, or barely equivalent to that for lighting two 16-CP incandescent lamps.

The fan motors illustrated are manufactured by the Interior Conduit & Insulation Company, 527 West Thirty-fourth Street, New York.

LUNDELL ELECTROLIER CEILING FAN.



LUNDELL ALTERNATING-CURRENT FAN.

C. & C. IRONCLAD MOTOR.

The motor shown in the accompanying illustration is of the four-pole type, with a number of special features, both electrical and mechanical.

The frame, which consists of a soft steel shell with radial poles, is capped at each end with a circular end plate, which carries the bearings and also the rocker arm support. The magnet coils are interchangeable and may be readily removed after taking out the armature.

The armature is of the drum type, built up of thin laminæ of soft iron, well insulated to provide against eddy currents, and having the conductors laid in slots, the coils being wound on forms.

The brush support is designed to secure mechanical rigidity and to obviate any humming noise. The brush-holders are of the well-known reaction type, securing a flexible and even pressure with a minimum of wear; the design is such that the brushes maintain a constant relative position on the commutator, thereby providing against the necessity of shifting the brushes forward when they have been shortened by wear. The bearings are self-oiling, with large oil wells providing an ample quantity of clear oil for lubricating purposes.

The cylindrical form of this machine makes it well adapted to all cases of direct connection, either through gears or otherwise. The gear shaft boxes can be placed on the shell at any convenient position, as the distance from the shaft to the outside of the shell is everywhere the same. The machine itself can be placed in any horizontal position, thus making it well adapted to run as a ceiling motor, or to attach at any angle to an "A" frame, or to bolt on the bed-plate of any machine or tool with which it may be combined, the circular form of the end plates allowing it to be bolted on with the oil wells always in the proper position.

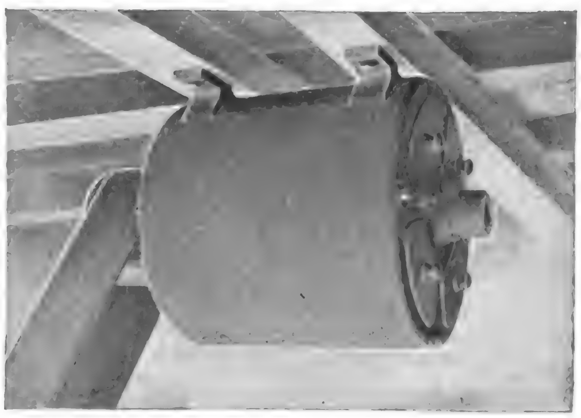
The ironclad magnetic field is extremely compact, its circuits being of minimum length with freedom from "external field" or magnetic leakage. While providing an ironclad type of field, the outer shell also forms a protection to the motor—a specially valuable feature where dust or dirt or dampness is apt to occur, and in fact, in any location where employes are liable to be careless with reference to the motor. None of the moving parts, except the pulley, pinion or coupling, is outside of the shell, which secures safety not only to the operator, but also to the armature of the machine.

As the shell is of steel ⅝ in. or more thick, it may be tapped into wherever desirable, as in a case of direct application to machine tools or other classes of machinery, provided iron bolts are used; thus making the motor form part of the framework as well as the driving power.

The motor is furnished, when required, with speed regulation by means of a field controller, giving a speed range of from full speed down to two-thirds of full speed with a proportionate output; this avoids the use of series controllers where they may be objectionable. It is also supplied back geared to any desired speed, making a very compact and efficient motor for driving at slow speed; or with back shaft and change gears, making it possible to obtain a range of speeds on the driving shaft by changing the gears, requiring only a moment's time and involving the use of no rheostats whatever.

Among the claims made for this motor are that it has a wider range of application than any other type, as it can be belted, back-geared, direct connected or furnished with change gears to drive at a range of speeds, or be run in any horizontal position whatever, inverted or otherwise; it is besides, dirt and dust-proof and has a high efficiency under all the above conditions.

The motor above described is made by the C. & C. Electric Company, 143 Liberty Street, New York.



C. & C. IRON CLAD MOTOR.

WEATHER-PROOF SOCKET.

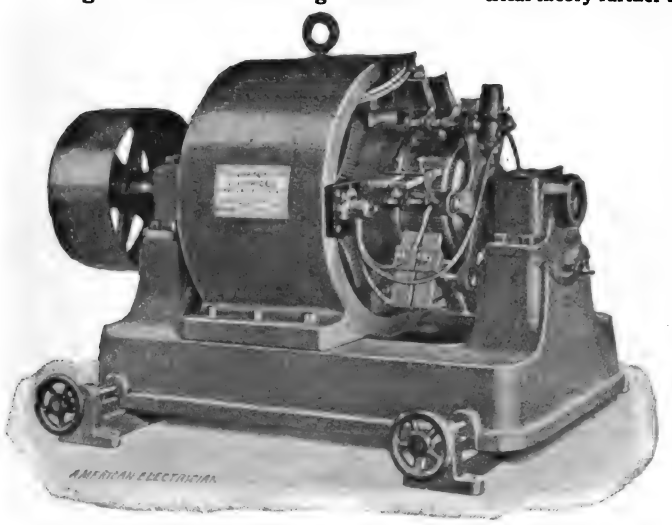
One of the particular features of the weather-proof socket shown in the accompanying illustration, is in the method of sealing in the wires, which makes the socket absolutely damp-proof. As will be seen, the porcelain skirt is unusually long, fully covering the lamp base. In addition to outdoor use, the socket is particularly adapted for breweries, dye houses and other damp places, where it will give eminent satisfaction, which is too frequently not the case with some types of so-called weather-proof sockets used in such locations.

The socket is made by the Bryant Electric Company, Bridgeport, Conn., for T.-H. and Westinghouse bases.

WEATHER-PROOF SOCKET.

QUAKER CITY GENERATOR.

The generator shownin the accompanying engraving is solid, substantial and compact in construction, with a lowcenter of gravity and weight well distributed over an ample bed-plate. The bearings are self-oiling, with large bronze metal bushings and double



QUAKER CITY GENERATOR.

oil rings in each journal. The magnet coils are interchangeable, being machine wound on standard forms. The field rings, being separable from the bed-plate, may be mounted on special bed-plates for direct connection to any of the standard types of automatic engines.

The machines are smooth running, of high electrical efficiency, and are claimed by the makers to be capable of developing their full rated output without over-heating, and, owing to the generons proportions of the commutator and brush capacity, without sparking.

The laminated core is solidly built and slotted to receive the winding. While both ends of the core are practically enclosed, there are openings in the fibre head which communicate directly to the interior of the core, affording exceptionally effective ventilation.

The commutator is massive. The materials used are tempered copper segments with mica insulation. The segments are very deep, affording large available surface for wear, and the generous proportion of the whole insures excellent operation under all conditions. The winding is accurately done in the slots arranged for that purpose, and is carefully insulated. The armature is well proportioned, perfectly balanced and is in all respects equal to the most stringent requirements of modern armature construction.

The Quaker City Electric Company, Philadelphia, Pa., are the manufacturers.

NEW BOOKS.

THE ELECTRIC MOTOR AND THE TRANSMISSION OF POWER. By Edwin J. Houston and A. E. Kennelly. New York: The W. J. Johnston Company. 377 pages, 122 illustrations. Price, $1.

This handsome little volume will be found of interest by all classes of readers. It will enable those not specially trained in electro-technics to form an intelligent idea of the principles, construction and operation of the electric motor, while in its pages the student will find the elementary principles he requires uncumbered with mathematics or purely scientific detail. The chapters on the electrical transmission of power, alternating-current motors and rotating magnetic field will be found particularly satisfactory.

WIRING TABLES. How They Are Made and How to Use Them. By Thomas G. Grier. Chicago: Thomas G. Grier. 75 pages, 76 illustrations. Price, $1.

To the wireman who does not care for any electrical theory further than necessary to comprehend the principles underlying the calculation of wiring, this little book will prove useful. The ohm, volt and ampere and their relations to each other, are very simply discussed, and application of the information thus given is made to the calculation of wiring. Methods of wiring are also treated and a full set of wiring tables given to meet all of the cases that usually arise in practice, ranging from 50 to 5000 volts. Other tables on resistances, weights, etc., of wires are included and there is a final chapter on the circuit breaker.

ELEMENTARY TEXT-BOOK OF PHYSICS. By Prof. Wm. A. Anthony and Prof. Cyrus F. Brackett. Revised by Prof. Wm. F. Magie. Eighth edition, NewYork: John Wiley & Sons. 512 pages, 15 illustrations. Price, $2.50.

That this excellent text-book has reached an eighth edition is in itself a sufficient testimonial to its merits. The most notable change made in the revision of this edition is in the treatment of magnetism and electricity by the method of tubes of force. While the conception of tubes of force may be useful in the consideration of dielectric stresses, it is doubtful if it is suited for the explanation of electrical and magnetic phenomena to the beginner. owing to its abstract nature. The author himself states that "Thomson gives no mechanical explanation of the properties which these tubes must be assumed to have, only saying that 'the analogies between their properties and those of the tubes of vortex motion irresistibly suggest that we should look to the rotary motion in the ether for this explanation.'" On page 252 the statement is made "For any boiler pressure which it is safe to carry in practice, it is not possible, even with a perfect engine, to convert into work more than about 15 per cent. of the heat used." The 15 is evidently a slip of the pen, as with an initial pressure of 185 lbs. gauge and a vacuum of 26 ins., the efficiency of the perfect engine would be 30 per cent.

TRADE PUBLICATIONS.

Walker Generators. The current Walker circular has for its text the armature of the Walker generator, the special features of which are brought out by several striking pictorial comparisons.

Care of Commutators. Mr. Charles Wirt, 1028 Filbert Street, Philadelphia, has republished in pamphlet form an article on the "Care of Commutators," which contains much information of practical value. Our readers can obtain a copy upon application to the author.

Fan Motors. In a handsome pamphlet the Western Electric Company illustrates and describes its 1897 models of fan motors, which embrace almost fifty different designs and sizes. The various illustrations show some of the more prominent types, and detail views enable the design of the motors to be clearly understood.

Electric Light Supplies. Stanley & Patterson, 32 Frankfort Street, New York, have issued a ninth edition of their catalogue of electric light equipment supplies, which contains no less than 272 pages. The illustrations number more than 500, and represent every form of equipment and supply from a large generator to a lag screw.

Alternating-Current Fan Motors. The neatness of the design of the induction motors made by the Emerson Electric Manufacturing Company, St. Louis, Mo., is well illustrated in a catalogue just issued, in which the various 1897 models are shown. Full descriptions and detail illustrations are included, together with instructions for setting up and care.

Gasoline Trucks. The Clayton & Lambert Manufacturing Company, Ypsilanti, Mich., has issued a handsome catalogue which, under the title of "Gasoline Fires," illustrates and describes almost a score of different forms of gasoline torches and pots. Among these are two electricians' fire-pots and four different types of blow-torches especially made for electrical work.

Corliss Engines. In a 32-page catalogue issued by the St. Louis Iron & Machine Works, the "St. Louis Corliss Engine" is illustrated in detail and a number of half-tone views given of the simple and compound types manufactured. The descriptions accompanying the illustrations will be of value to those who wish to follow the latest modern development of the Corliss engine.

Preservative Paint. Edward Smith & Company, 45 Broadway, New York, in a large octavo pamphlet, print a number of papers read before professional societies dealing with the application of paints, varnishes and enamels to the protection of iron and steel structures. The volume forms a useful and up-to-date treatise on the subject, the only direct advertising matter being reserved for the final page of the book.

Impulse Power Wheels. In a handsomely cloth-bound cover of over 80 pages, the American Impulse Wheel Company, 120 Liberty Street, New York, gives a treatise on the Cazin impulse wheel, recently introduced on the market. Demonstrations, supported by quotations from recognized authorities, are given in substantiation of the claims made for this type of impulse wheel, and many pages of valuable hydraulic data are scattered throughout the book.

Machine Tools. The Garvin Machine Company has marked the occupancy of its magnificent quarters at Spring and Varick Streets, New York—the handsomest metal-working factory in the world—by the issue of a 160-page catalogue of the machine tools of its manufacture. Over a hundred different types of tools are described and illustrated, forming a most exhaustive exhibit in a line of manufacture in which the United States easily takes the lead of the world.

Electric Heating Appliances. The Electric Appliance Company, Chicago, is putting on the market a line of electric tailoring and laundry irons for which great claims are made. It goes without saying that the best work can be accomplished with an iron which can be kept constantly at a uniform temperature, and this can only be accomplished with an electric iron. The Electric Appliance Company is prepared to send a special circular of this line of goods on application.

Fan Motors and Ventilating Apparatus. The Central Electric Company, Chicago, well understands the art of catalogue making, which statement is amply sustained by its latest production—a 32-page pamphlet devoted to fan motors and ventilating apparatus. The cover is a beautiful design and the illustrations accompanying the text are well brought out by being printed on paper of excellent quality. A score or more of types of electric fans are illustrated and described, including battery motors with battery outfit.

Lundell Fan Motors. In a well printed and illustrated catalogue the Interior Conduit & Insulation Company, New York, shows the various types of its 1897 model fan motors, which include all of the many forms now in use, most of which were originated with this company in its pioneer work in this line. One feature of the catalogue that will be particularly appreciated are the detail illustrations given of the Lundell fan motor, which clearly show the construction of every minute part.

BUSINESS NEWS.

Removal Notice. The Holtzer-Cabot Electric Company, of Boston, Mass., has removed its New York branch office to 112 Liberty Street.

C. L. Pullman's Center Vestibule Car Company has moved its offices from 806 Fisher Building to Nos. 653 and 655 Rookery Building, Chicago.

Mr. W. L. Fairchild, formerly with the Westinghouse Electric & Manufacturing Company, Syracuse, has been appointed general agent for the Onondaga Dynamo Company, of Syracuse, with offices at 39 Cortlandt Street, New York City.

Ball Engines. An electric light plant has lately been placed in the Wauwatosa County Insane Asylum, Wisconsin. The Ball Engine Company,

Erie, Pa., furnished the engines. The direct-connected engines and dynamos for the Chicago Public Library are now being put in position. The Chicago Edison Company furnished the dynamos, and the Ball Engine Company the engines. The plant consists of five direct-connected sets, amounting to 900 HP.

Induction Motors. The General Electric Company has received an order for several hundred alternating-current induction motors, to be used to operate the Tuerk ceiling fan, manufactured by the Hunter Fan & Motor Company, of Fulton, N. Y. This is a high endorsement of the alternating-current induction motor, inasmuch as hundreds of these motors were used last year for operating Tuerk ceiling fans, to the entire satisfaction of the Hunter Company.

Trade at Indianapolis, Ind. The Fryer & Fleming Electric Company, of Indianapolis, reports a successful business for the month. This firm has just completed repairs for a 1000-light Slattery alternator and overhauled all the motors for the Broad Ripple & Rapid Transit Railway Company, of Indianapolis. Judging from the activity in this company's shops, one would be inclined to believe that Messrs. Fryer & Fleming have the inside track on repair work in Indiana.

Export of Pulleys. The Rockwood Manufacturing Company, Indianapolis, Ind., has just filled a large order for its special pulleys to be sent to Osaka, Japan. This makes the ninth order received from the General Electric Company for export to this particular place, besides many other large orders for other parts of the world. The demand for these pulleys has increased very rapidly in the past few years, and the many duplicate orders received indicate that the Rockwood paper pulley gives universal satisfaction.

Telephone Business at St. Louis. The Missouri Telephone Manufacturing Company, 917-19 Market Street, St. Louis, states that it is running overtime and has about all the business it can handle without increasing its facilities. Judging from the first-class line of goods which this company manufactures, and its energetic and able way of presenting these goods to the trade, it is needless to state that it is maintaining its well known reputation for strictly first-class work. Among recent installations for complete service is a new exchange at Valley City, N. Dak., one at San Jose, Cal., and also one at Stanbery, Mo.

Street Railway Commutators. The Morrell Electrical Works, 3139 Olive Street, St. Louis, reports a decided increase in business for the present month and states that prospects are very bright. This firm has taken up as a specialty the manufacture of assembled commutators for street railways. The material used is hard drawn and is of the best quality of Lake Superior copper. Among recent orders received by this firm is one for G. E.-800 type from the Citizens' Street Railway of St. Louis, some fifty in all. It has also recently filled an order from the Suburban Railway for G. E.-1200 commutators and from the National Street Railway for G. E.-800 and the old style F-30.

Electrical Engineering at Springfield, Ill. The Haas Electric & Manufacturing Company, Springfield, Ill., carries one of the finest and largest stocks of fixtures and electrical supplies, plumbing and heating appliances, in central or southern Illinois. This company has just finished a complete installation for the Odd Fellows' new temple at Springfield. This installation includes a battery of 160-HP Drake boilers, an 800-light D. C. plant, an Ideal engine and National multipolar generator. It also installed the vacuum steam heating system, the plumbing and all electrical fixtures. This particular plant is one of the most economical in operation in the country.

Pole Line Material. The Central Manufacturing Company, of Chattanooga, Tenn., manufacturer of yellow pine cross-arms, oak and locust insulator pins and brackets and electrical mouldings, reports a very satisfactory business throughout the United States. It has just completed arrangements for extending its business to foreign countries, and is already receiving inquiries for its goods from Mexico, South America, Germany, etc. This company furnished the pins and cross-arms for the Niagara Falls transmission lines, which experts report to be the finest construction work ever erected in this country. It will be pleased to answer all inquiries concerning the material in which it deals.

Electric Railway Air Brakes. The Standard Air-Brake Company during April closed contracts with the Dighton, Somerset & Swansea Street Railway Company, of Taunton, Mass., the Commonwealth Avenue Street Railway Company, of Boston, Mass., and through their foreign agents, for air brakes on the Continent. The company is also supplying to the Pennsylvania State College, Department of Electrical Engineering, for use on its experimental line, which has been built to teach the students practically, a complete working outfit showing the operation of the "Standard" system. A recent item from the *Morning Herald*, of Sydney, Australia, speaks highly of the operation of the Standard brake, lately installed on a tramway line running from that city.

The Phœnix Automatic Filter Company, Racine, Wis., has made arrangements whereby the well known Tracy patent oil filters, manufactured only by this firm, can be obtained from the following well known supply houses: Manning, Maxwell & Moore, 111 Liberty Street, New York; Brown Bros. Company, Providence, R. I.; Reuter & Mallory, Baltimore, Md.; National Oil Works & Mill Supply Company, New Orleans, La.; N. O. Nelson Manufacturing Company, St. Louis, Mo.; the Bradford Belting Company, Cincinnati, O.; Geo. T. Clarkson Company, Pittsburgh, Pa.; Central Electric Company and Chicago Engineer Supply Company, Chicago, Ill.; Hendrie & Bolthoff Manufacturing Company, Denver, Col.; Abner Doble Company, San Francisco, Cal.

American-Ball Engines and Generators. The American Engine Company, Bound Brook, N. J., has just begun the shipment of its new direct-connected generating plants, in which the American-Ball engine is combined with its new line of six-pole generators. It is now installing a 75-KW plant at No. 7 East 17th Street, New York, in the building of Deitsch Brothers, and a 35-KW plant in the building of the *Evening Wisconsin* of Milwaukee. In addition to this it has orders from the Philadelphia *Enquirer* for a 100-KW plant; the Buffalo *Evening News* a 35-KW plant; the Phelp's Publishing Company, of Springfield, Mass., two 35-KW plants; the New York *Tribune* a 75-KW plant; and the World's Dispensary Medical Association, of Buffalo, a 25-KW plant.

Suit for Damages for Failure to Deliver Copper. An interesting case in the Supreme Court, of New York, was disposed of recently by the discontinuance of the suit of the Okonite Company against Holmes, Booth & Haydens. The complaint showed that in June, 1895, Holmes, Booth & Haydens sold to the Okonite Company 300,000 lbs. of copper at 12¼ cents, and after delivering 50,509 lbs., stopped further delivery. The Okonite Company then, in September, 1895, purchased elsewhere the balance of the copper at fourteen cents, and then sued Holmes, Booth & Haydens for about $4500, the difference. Holmes, Booth & Haydens denied the contract. An order discontinuing the suit was entered in the Clerk's Office on the 21st, and on inquiry it is understood that Holmes, Booth & Haydens paid the Okonite Company about $2800 for a settlement.

The Standard Air-Brake Company, has increased its engineering staff by the addition of Mr. Edward H. Dewson, Jr., with whom General Manager Wessels lately closed a contract for a term of years, and who entered upon his new field on Apr. 26. Mr. Dewson brings to the company a ripe experience, and has been long and favorably known in connection with his work while with the General Electric Company in its engineering department, and in connection with locomotive practice and the superintendency of one of the Western lines. He has for some time filled the position of master mechanic for the Pratt & Letchworth Company, of Buffalo. Mr. Dewson is thoroughly posted on the mechanical arts and will find full scope for his ability in his new field. The annual meeting of the stockholders of the Standard Company was held at the company's office, 100 Broadway, New York, on Wednesday, Apr. 21. The following directors were elected to serve for the ensuing year: Henry Seligman, Edward J. Wessels, Albert Strauss; Leopold Wallach, Theodore Seligman and D.F. Meyer.

Assignment of George Cutter. The recent assignment made by George Cutter, of Chicago, was a great surprise to his friends and acquaintances in the electrical trade throughout the country. This assignment, we learn, was due entirely to some unfortunate real estate investments of Mr. Cutter. As a business man he is well known to be careful and conservative, and a thoroughly capable engineer with many friends and admirers in this country as well as Europe. He was for three years chief engineer of the Thomson-Houston Company, where he formed the acquaintance of many prominent electricians. In the early days he had charge of the testing department of the Thomson-Houston Company, and has kept in close touch with electric lighting apparatus ever since. He has marketed many valuable specialties which are used throughout the world. Mr. Cutter states that he expects soon to be actively enployed in some branch of electrical work in which his ability will be appreciated. His wide experience as an electrician and supply dealer renders him specially valuable as a manager of a central station. Should he accept such a position he would also likely arrange to carry on a manufacturing enterprise in the same town in connection therewith. The George Cutter Company will carry on the sale of his specialties, with offices in the Rookery Building, Chicago. Mr. Cutter has our best wishes for success and we congratulate the lighting or power company that secures his services.

A New Construction Company.—The Chase Construction Company, of Detroit, Mich., has just been incorporated with an authorized capital of $25,000. The company will devote itself to construction and equipment of central station lighting, electric railways and steam and water works plants, having just secured a contract to build the electric railway running between Cleveland and Lorain, O., for the Lorain & Cleveland Electric Railway Company, which is to be completed by June 1. The officers of the company are: George E. Fisher, president and treasurer; O. D. Chase, secretary and chief of engineering department, and E. N. Chase, vice-president and superintendent of construction. The active men in the company are pioneers in the electrical business. O. D. Chase, whose name the company bears, was electrician and superintendent of the Commercial Electric Engineering Company, while George E. Fisher, was its business manager. During the term of the Commercial Company's existence, they installed 58 central station lighting plants and 167 isolated plants, in addition to a large volume of other electrical work. The Chase Construction Company has secured the services of E. F. Mann, as superintendent of railway construction, a practical man of large experience in railway work, having superintended the construction of the immense system of the Detroit Electric Railway Company, Niagara Falls, Toronto, and a number of the Cleveland roads, covering a period of twelve years. The company has handsome offices in the new Majestic Building, in Detroit, and anticipates a very active business during the coming season.

The New Power Transmission. The Bullock Manufacturing Company, of Cincinnati, O., which, it will be remembered, was formerly known as the Card Electric Motor & Dynamo Company, of the same city, has become closely identified with the rapidly extending system of direct-connected power transmission for factories and printing establishments in the East, as well as the West. Although it has been actively represented in this territory for only eighteen months, it has established a reputation and an organization capable of handling entire power and light equipments for factories, office buildings, newspaper plants, etc. Among the notable examples of the new system of power transmission may be mentioned the Mergenthaler Linotype Company, Ryerson Street, Brooklyn, N. Y., in which all of the countershafts are driven by direct-connected, slow-speed motors; the Heide factory, Vandam Street, New York—a new modern steel structure, in which all the countershafts are driven by direct-connected motors, some sixteen in number, ranging in speed from 180 to 300 r. p. m., and in horse power from 3 to 30. Among the newspaper equipments may be mentioned the New York *Journal*, in which two Hoe sextuple color presses are operated by direct-connected motors; New York *Herald*, one Hoe quadruple press; New York *Times*, one Scott press; Paterson *Sunday News*, one newspaper press; American Book Company, *Munsey's Magazine*, using thirty-five motors and three generators; Textile Publishing Company. Winthrop press. Among the lighting plants installed are the following: The new St. Bartholomew's Parish House, Forty-second Street, New York; Haight Building, Broadway, New York; J. J. Harrington & Company; Daiger Apartment House, etc., etc. The company reports brilliant prospects for future business, especially for power transmission, the new system of which is agitating the minds of progressive manufacturers and engineers.

American Electrician.

Vol. IX. New York, June, 1897. No. 6.

A MODERN AMERICAN CENTRAL STATION.

BY F. W. ROLLER.

A STATION which may be taken as representative of recent practice for the average conditions presented by the smaller cities in this country is found in the plant of the Suburban Electric Company, Elizabeth, N. J. This company erected its station on the present site in 1892, using an equipment of Corliss engines belted to jack-shafting, driving a number of alternating, arc and low-tension, direct-current dynamos.

The alternating current was single phase of a line voltage of 1000, and used solely for lighting; the arc system was for the lighting of the streets of Elizabeth itself, while the low-tension service was three-wire, used principally for running motors for different classes of service. On this basis the company was doing a remunerative and constantly increasing business, when the station, or at least the major part of it, was destroyed by fire on June 19, 1893. In the boiler room, which had escaped comparatively unharmed, and in a modern building built in the rear, was put a temporary equipment, which furnished current while the apparatus about to be described was being installed.

To understand intelligently the conditions, reference should be made to Fig. 2, showing the location of the station in regard to the main lines emanating therefrom. Of course, the principal demand for current is from the city of Elizabeth, including Elizabethport, but besides this, service is given to Lorraine, Roselle, Aldine, Cranford and Westfield, the centre of distribution in the latter town being 7½ miles from the station.

The distribution of the load along these lines is such that the station location falls almost exactly central to the output. The site has the further advantage of being on the banks of a creek, from which an abundant supply of water for boiler feed and condensation purposes is obtained, and in addition is within a very short distance of the tracks of the main line of the Pennsylvania Railroad, so that coal can be cheaply delivered in bulk.

In rebuilding the plant it was decided to make everything conform to the best engineering practice of the time, utilizing, nevertheless, as much of the old steam apparatus (no electrical apparatus having been saved from the fire) as was available.

We may start in with a description of the station in its present condition at the

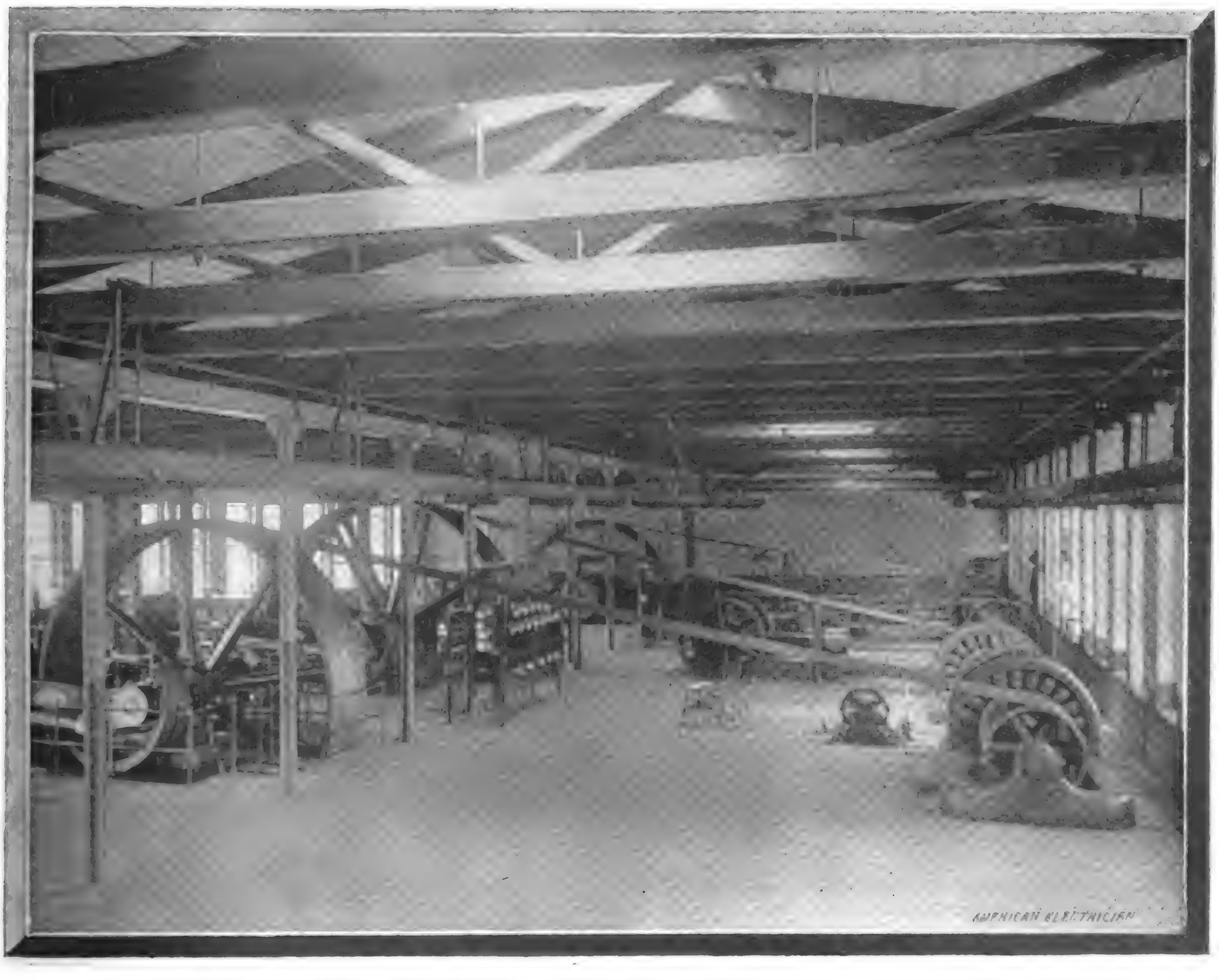


FIG. 1.—GENERAL VIEW OF ENGINE AND DYNAMO ROOM OF ELIZABETH STATION.

boiler plant, an excellent idea of the appearance of which may be gained from Fig. 3, the arrangement being shown in

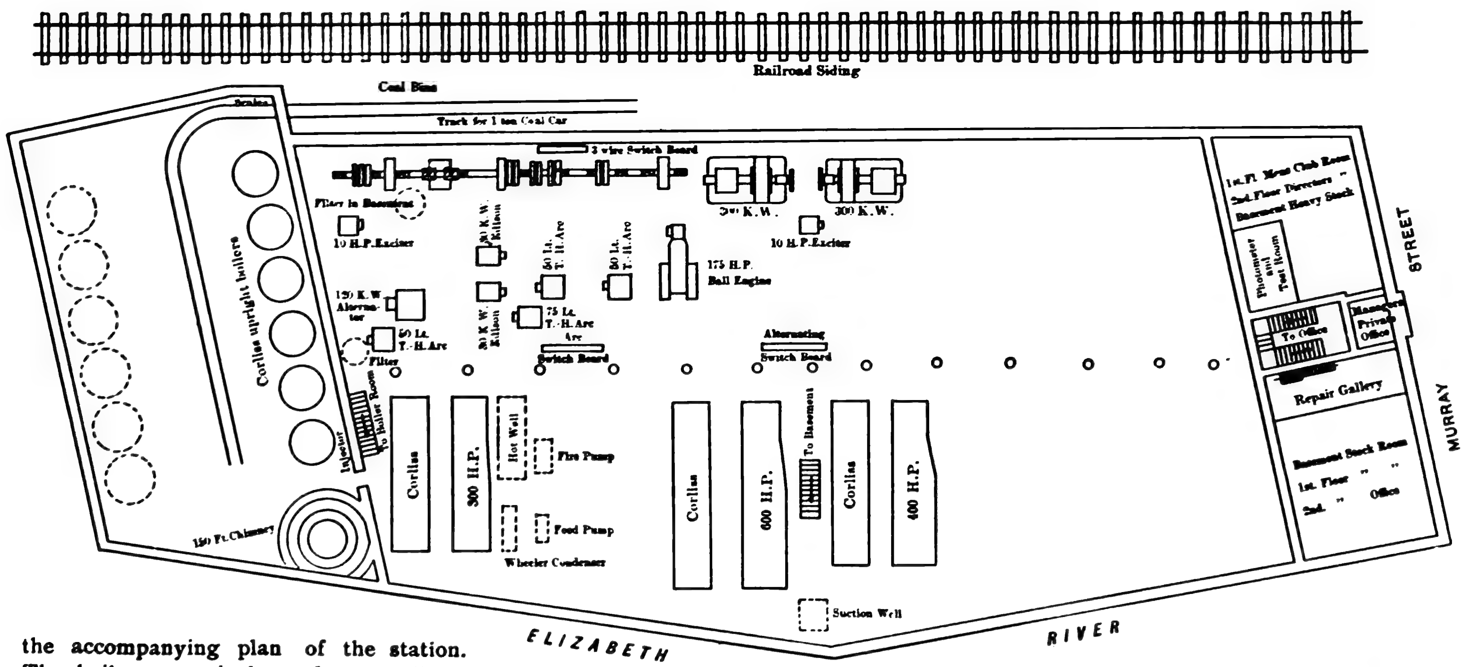
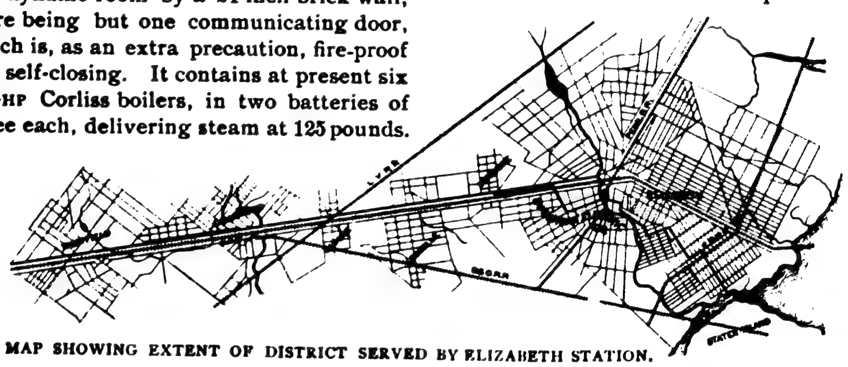


FIG. 2.—PLAN OF ELIZABETH STATION.

the accompanying plan of the station. The boiler room is located, as will be seen from Fig. 2, at one end of the station and entirely separated from the engine and dynamo room by a 24 inch brick wall, there being but one communicating door, which is, as an extra precaution, fire-proof and self-closing. It contains at present six 160-HP Corliss boilers, in two batteries of three each, delivering steam at 125 pounds.



MAP SHOWING EXTENT OF DISTRICT SERVED BY ELIZABETH STATION.

Being vertical fire-tube boilers, sufficient length of tube in the steam space is exposed to the action of the hot gases, so that the steam is slightly superheated, the amount of superheat being regulated to some extent by the height of water carried. As a result the engines receive practically dry steam, so little water in fact being noticed that only one of them, and that nearest the boiler, is supplied with a separator, the other drawing directly from the main with absolutely no trouble.

Each battery of boilers has a separate ecconomizer provided with a by-pass flue for use when the economizer is to be overhauled. The main flue leading to the stack is of double the cross section needed at present, and is arranged in all respects so that when additional boilers for which space is left are installed no further alterations will be necessary. Coal is received by the carload over a spur from the railroad onto a trestle work over the coal bins, and unloaded into them. From the bins it is taken as needed on a one-ton dumping car running on a track through the boiler room, each load being weighed on its passage by a platform scales, on which is built a small section of track.

The coal, which is soft bituminous, is stoked entirely by hand and burnt on the natural draught given by the huge 150-foot round brick chimney, a view of which is given in the initial cut.

It has been found unnecessary to pass the feed-water through a purifier; simple filtration and the use of small quantities of kerosene oil, fed in through a sight-feed lubricator, leaving the water in such condition that there is only a slight and very easily removable scale formed on the tubes and other water surfaces of the boilers.

The boilers are interconnected by a ring system of mains, with a suitable arrangement of valves, this giving almost absolute safety against shut-downs due to leaks or accidents.

A noticeable feature of the boiler room is its lightness and airiness, the temperature being as low, or even lower than in any other portion of the building, even the offices having no advantage in this respect.

Leaving the boiler room, we enter the space under the engine room floor or basement. This (Fig 6.) is well lighted by a row of windows opening on the creek and extending nearly the whole length of the station. Here are contained all the steam and other piping connections for the plant.

FIG. 3.—BOILER ROOM.

The condensers and their pumps, the hot well, a Snow and other pumps, are also in-

stalled here, and we find as well a small machine shop capable of taking care of any light repair work that may have to be done.

Passing through here, we ascend a short flight of stairs and find ourselves in the

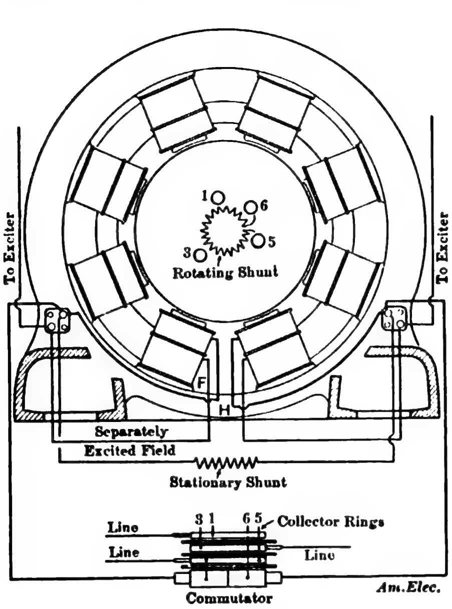


FIG. 4.—CONNECTIONS OF MONOCYCLIC MACHINE.

engine room, a general view of which is given in Fig. 1.

As is seen from this, the engine equipment consists of three large engines. The smallest of these is a nominal 300-HP, cross compound, condensing Corliss engine fitted with a Wheeler condenser and belted to a line of jack-shafting, and the other two are 400 and 600 HP respectively, of the same type, but fitted with jet condensers, each engine being direct belted to a 300-KW generator.

The 600-HP engine is, of course, much too large for its present load, but arrangements are being made to connect it also to the jack-shaft, so that it may assist the smaller engine at the time of heavy load. It and its companion were both in use before the fire, but have had their valve gear and fly-wheels entirely rebuilt.

The engines have both cylinders jacketed with live steam; all piping connections are made from beneath, leaving a clear floor, and the receivers, which, it may be remarked, have no appliances for reheating, are similarly disposed of.

In addition to the above engines there is a simple automatic high-speed Ball & Wood engine of a nominal capacity of 175 HP, adapted to drive the jack-shafting from one end through a clutch, and originally intended to carry the day load. It has been found, however, that the 300-HP Corliss engine, running condensing, gives good economy even when running light, so that the high-speed engine is now used simply as a reserve in case of accidents.

A number of interesting economies are practiced in the engineer's department, an account of which may prove of value. Prominent among them is the method of handling the oil. All of this, after being used, instead of being allowed to drip into the receptacles usually provided for that purpose is conveyed from each bearing by an elaborate system of piping to a closed tank in the basement. The oil from the jack-shaft bearings is led to the same point in a similar manner, and whenever enough has been collected the pump attached to the tank is started and the oil forced up and over a bridge across the creek to an oil house entirely detached from the station proper. There it flows into the upper part of a gravity purifier and is clarified by filtration. It is then again pumped to another tank in the upper part of the same house, whence it flows back across the bridge to an oil cupboard in the engine room.

A live-steam pipe is run to the oil house in the centre of the nest of pipes to keep the oil liquid enough to flow readily, and glass gauges over the cocks in the cupboard show at all times the amount of the various oils on hand. A further saving in oil is effected as follows: In the machine shop there is a large copper-lined wooden tank into which all the oily and dirty waste (from around the plant) is thrown after being used; this tank is kept partially filled with water, which is being constantly heated and agitated by a small stream of live steam blown in through a quarter-inch pipe. After the waste has remained in this bath for a while, not only is the oil entirely boiled out and left ready to strain off and pump over to the oil house, but all the grit is also removed and the waste, after drying, is again ready for use.

This inexpensive device has proven exceedingly satisfactory, as the net result of it and the oil-piping system mentioned has been that oil is only consumed at the rate of about one barrel per month, a truly remarkable showing for a station of this size.

The engine room has been built sufficiently large to allow the installation of two more 300-KW direct belted units.

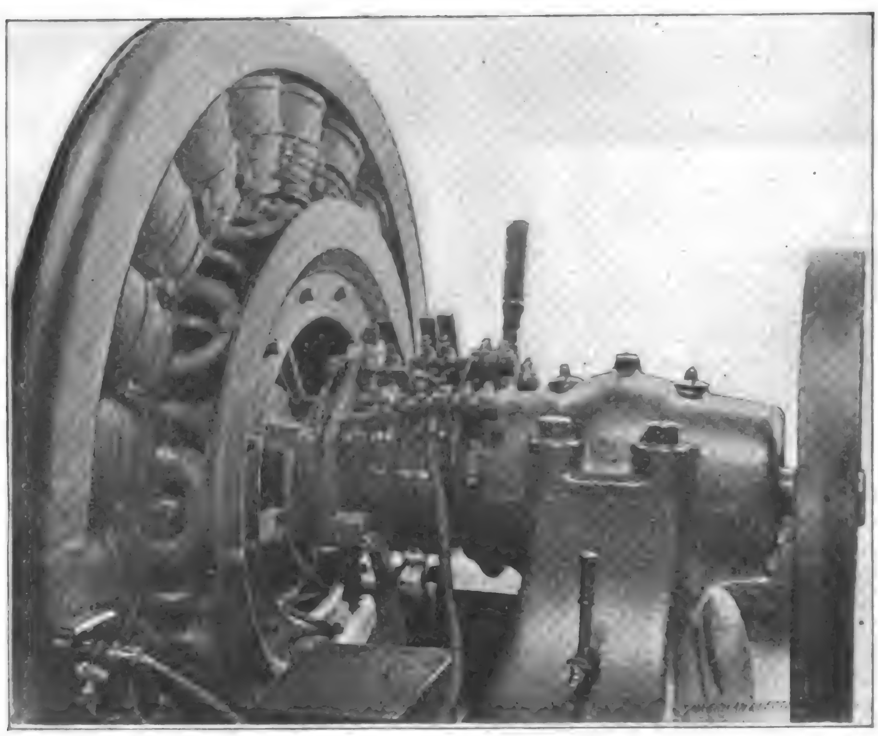


FIG. 5.—COMMUTATOR END OF MONOCYCLIC MACHINE.

The office, etc., occupies that portion of the building fronting on the street, and is separated from the engine and dynamo room by a brick wall and fire-proof doors. To the right as one enters is the employes' reading and recreation room, to the left the stock room. The reading room (Fig. 8) is fitted up with punching bag, chest weights, Indian clubs, etc., and supplied with papers and magazines, both general and technical. This room is open at all times to the employes, who have organized the "Suburban Athletic and Literary Club" and hold meetings and entertainments during the winter months. A portion of this room is partitioned off as a test room (Fig. 9), in which may be found a complete set of instruments for meter and other electrical testing, and also a photometer for lamp testing.

The stock room is provided with the usual shelves and closets, and over a portion of it is built a gallery, which is used for arc lamp and other light repairing.

Beneath the reading room and stock rooms is a large, dry basement, which is used for heavy stock. Above the reading room is the directors' room and above the stock room the office.

We may now return to the engine room and inspect the electrical part of the plant. Starting with the arc machine equipment, this presents no feature of special interest. There are three 50 and one 75-light standard T.-H. machines, and one 120-light Brush machine, each driven from a separate pulley on the jack-shaft.

The low-tension direct-current apparatus has no particular claim to our attention either, it consisting at present of a pair of 30-KW bipolar Edison generators belted from the jack-shaft and connected on the three-wire system, furnishing current chiefly for motor and fan work. This service is necessary because a similar one was used before the fire, and a number of

the company's customers own motors which it would have been necessary to replace with others had the system been abandoned.

There are, moreover, a number of electric elevators, for which no other service seems to be as suitable, and this character of load is increasing so rapidly that a pair of 100-KW machines will shortly be installed.

The interesting portion of the generator equipment is the set of monocyclic machines. These are among the first installed by the manufacturers, and they are particularly well adapted to the conditions to be met here. With the old plant the only motor business that could be profitably carried on was limited by the nature of the case to the city of Elizabeth itself. It would have been impractical to use a set of 240 or even 550-volt, direct-current mains for power throughout the neighboring towns on account of the high cost of the copper and the line construction, and at the same time a straight two- or three-phase service would have been unsuitable where the lamp load so largely predominates, both on account of their comparative lack of flexibility and the possibility of trouble from unbalancing. The prospects of a demand for power in the suburban towns seemed sufficient to warrant making provision for supplying such power, and the monocyclic system presented itself as the one best suited for the work, escaping, as it does, all the above objections.

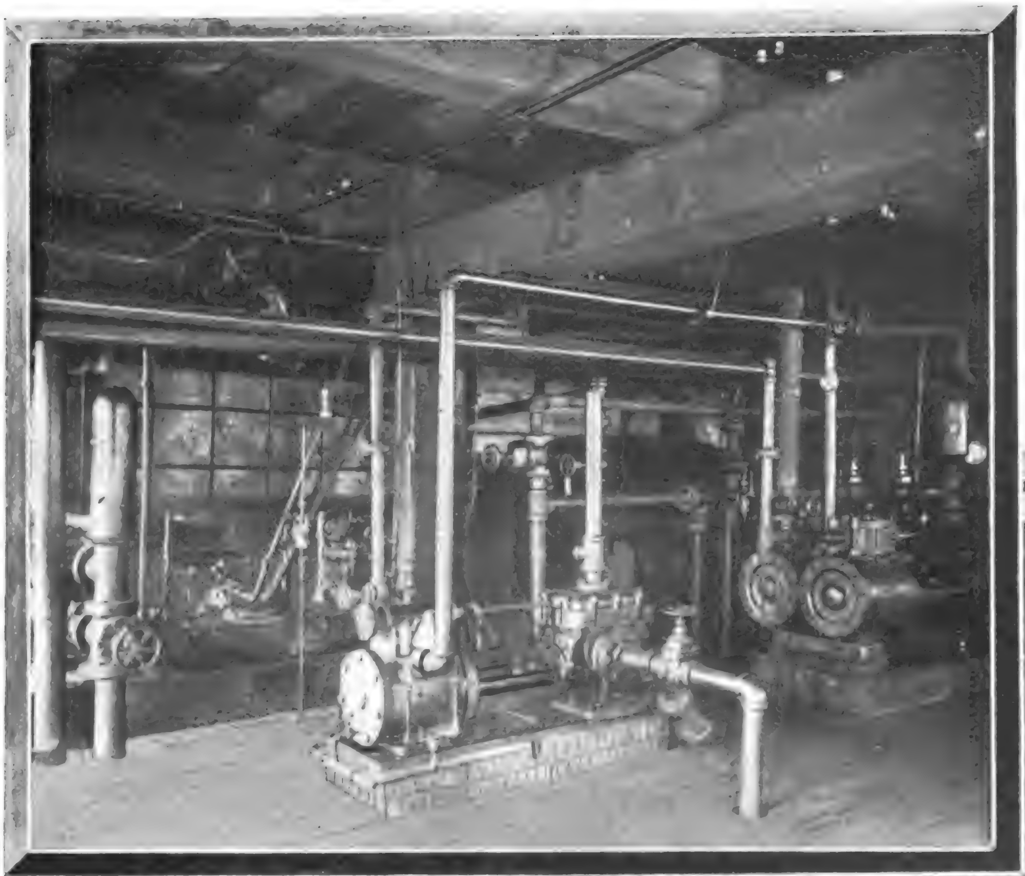


FIG. 6.—SURFACE CONDENSER, HOT-WELL, FEED AND FIRE PUMPS.

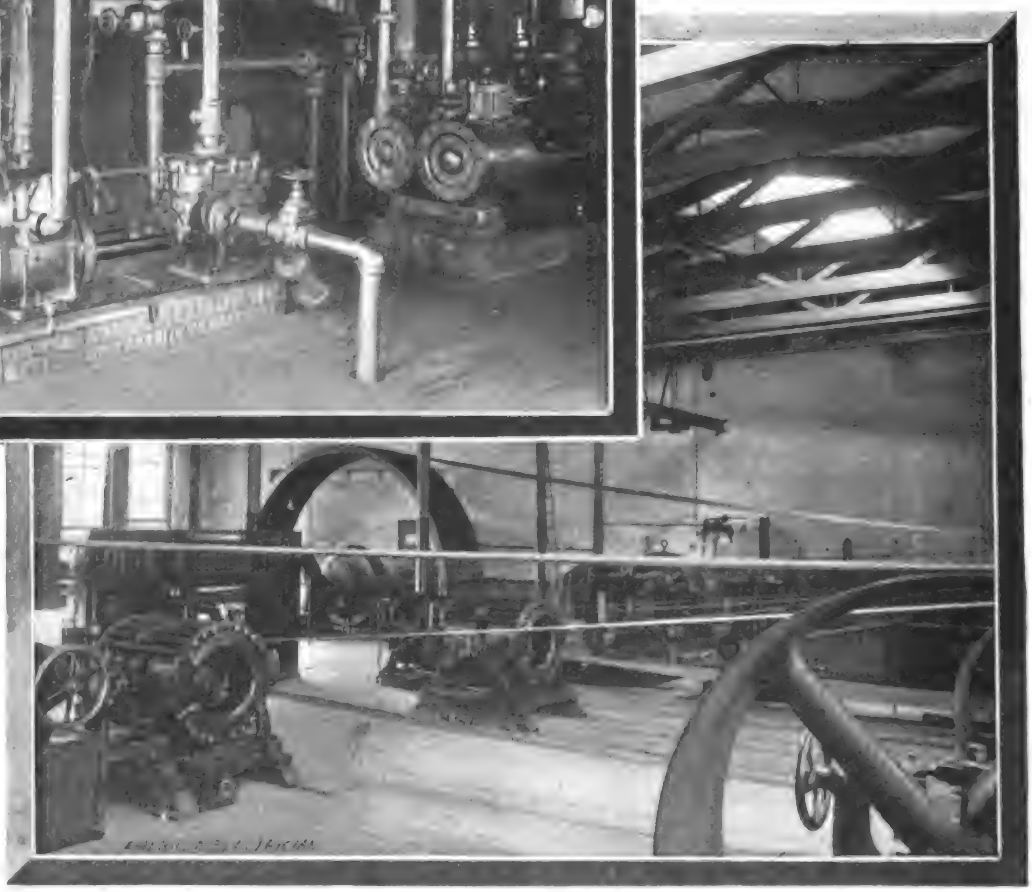


FIG. 7.—END OF DYNAMO ROOM.

It was therefore promptly decided to use this and at the same time double the old line voltage, so as to secure better regulation and less drop. Accordingly there were installed one 120-KW machine, belt-driven from the jack shaft which carries the power and day lighting load, and two 300-kw machines, each, as before mentioned, direct-belted to a large Corliss engine, which are started when the night lighting load comes on. The large machines shown in Figs. 1 and 5 have twenty poles each, and run at 360 r. p. m., giving a frequency of sixty cycles; the voltage across the main collector rings rises from 2,200 at no load to 2,300 at full load, the corresponding teazer voltages being 550 and 575, the compounding being effected in the usual manner by passing a portion of the main current through a rectifying commutator (Fig. 5), and then through the series fields. A diagrammatic representation of the connections is given in Fig. 4, and in Fig. 5 is given an end view of one of the large machines, showing the collecting devices in detail.

There are two exciters for the above machines, either of which is of sufficient capacity to excite all of them; one is driven from a small pulley on the shaft of one of the 300-KW generators, and the other is belted to the jack-shaft and is kept constantly running.

The wiring connections between the machines and their switch-board are made under the floor on the ceiling of the basement, passing down through at the generators and rising again behind the switch-board. This board is situated in the center of the engine room floor, is entirely separate from the arc and low-tension boards, and was specially designed and erected by the electrical engineer of the plant. Front and back views of it are shown in Figs. 10 and 11. It is built of slate, mounted on an iron frame and arranged to take care of three generator, two exciter and eight feeder circuits, all switches except those for the exciter carrying the high-tension current.

The front slab is really double, with all the actual current-carrying parts mounted on the rear pieces, the front one serving to form a complete guard for all switch-jaws, such that it requires deliberate effort to come in contact with them. The pockets thus formed are also very useful as an aid in quickly extinguishing any arc that may be drawn on breaking circuit.

The switches were specially designed for

this plant, and instead of three-pole switches each circuit is provided with two, one a double-pole for the main wires, and one a single-pole for the teazer wire, an arrangement not without its good points. There are two sets of both main and teazer bus bars, each energized from one of the large machines, the 120-KW generator having a double-throw switch so that it may be thrown onto either. As there is no synchronizing indicator provided, however, this paralleling has never been attempted.

The board is provided, as may be seen, with thirteen instruments, three voltmeters and ten ammeters, the latter showing the machine and circuit loads and the former the main machine voltages, no measurement of the teazer voltage being attempted. The machine and exciter rheostats of the Carpenter type are mounted on the back of the board, as are also the fuses and the type L, G. E. magnetic blow-out lightning arresters, the choking coils for the latter being suspended just above the board. As an additional precaution, all current-carrying parts, and even the iron supporting frame, are insulated from the slate by fibre bushings and washers to prevent any possibility of leakage through any semi-conducting veins. The results have been very satisfactory on the vol age used.

The commercial incandescent lighting in Elizabeth and Elizabethport is accomplished by an alternating three-wire system extending through the principal streets. This system is fed from 15,000-watt transformers installed at convenient points, both primary and secondary wires being banked in multiple. This arrangement is also carried out in the business centres of the suburban towns. One great advantage of an alternating three-wire secondary system over a direct-current system lies in the fact that no great precautions have to be taken to keep both sides of the system in perfect balance, any unbalancing being equalized by the transformers themselves.

For residence lighting individual transformers are avoided wherever possible, and two or more houses are supplied from one transformer. In some places it has been possible to supply as many as fifteen houses from a single transformer having a three-wire secondary winding. The arrangement of banking two or more transformers, as mentioned above, has been successfully used for residence lighting, and in some cases as many as thirty-five houses have been supplied from such a system.

The advantages of this arrangement are readily appreciated when the losses from a large number of small transformers are compared to those of a small number of large ones.

The experience of this station, which supplies nearly 400 residences, has been that but seldom do residences draw upon transformers for more than from 15 to 25 per cent. of the number of lamps connected. Where conditions are such that an individual transformer has to be installed, of course a comparatively larger transformer is used to provide for a possible chance of a larger number of lights being used at one time. Even in such cases the transformer never has a capacity of more than 50 per cent., and often runs as low as 30 per cent. of the number of lights in the house. As yet there has never been a transformer supplying a house burned out from overload.

Where several houses are supplied from one large transformer it is safe to assume that all the houses will never make a heavy demand on the transformer at the same time. As many as fifteen houses, having a total light capacity of over 300, have been supplied from a single 100-light transformer, and on one of the three-wire systems mentioned above three 100-light transformers supply houses whose aggregate light capacity is over 700.

Service wires, as a rule, are brought in at the top of the house, a few underground services being installed. Thomson recording wattmeters are used in every residence, current being sold by the kilowatt-hour.

FIG. 9.—TEST ROOM.

FIG. 8.—EMPLOYES' READING ROOM.

All transformers are placed on poles, and under no condition is one placed either outside or inside a building, even the station transformer being on a pole outside.

No provision was at first made for recording instruments, but the desirability of having them soon became evident, and a separate frame was erected behind the board, on which were mounted three Thomson recording wattmeters, one for each generator. These wattmeters are the first to be installed for primary monocyclic work and differ from the regular primary meters in that both sides of the circuit enter the meter, each field coil being energized by one side.

The switchboards for the arc and low-tension services are of the ordinary types. The former has the usual plug switches, with porcelain tubes surrounding the contacts to blow out the arcs when circuits are broken, and is of the common slate and iron construction. No instruments beyond a magneto for line testing are mounted on it, but provision is made by a suitable number of spring jacks to allow a portable ammeter to be plugged in when readings are desired.

The low-tension switchboard is of the old skeleton construction and placed against the station wall. This board is shortly to be replaced by a larger one to accommodate additional machines.

The streets in Elizabeth are lighted, as has already been stated, by ordinary series arc lamps.

The towns of Roselle, Cranford and Westfield are each lighted by about 175 incandescent lamps, there being separate mains from the station running to each town. These lamps are operated in multiple from a number of transformers, each transformer supplying a certain district. Where the secondary lines are long, two transformers are installed in series, thus making a small three-wire system with lamps alternately on either side and reducing the line drop to a minimum.

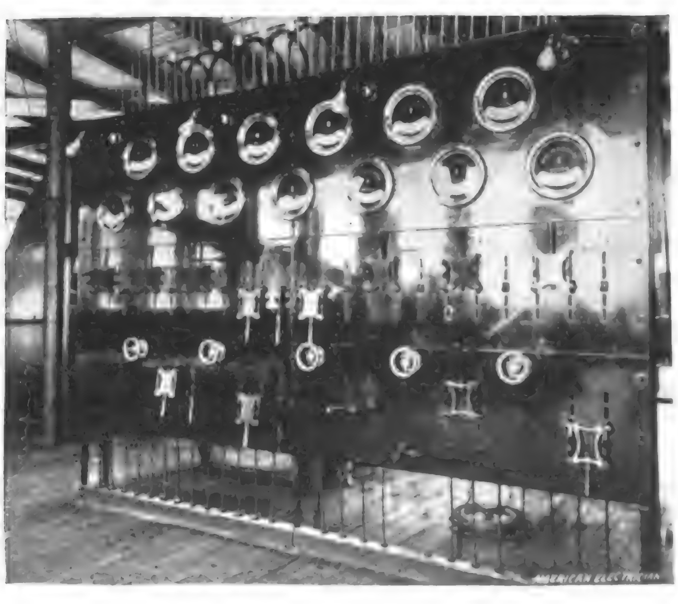
While this plan is not quite as economical either in first cost or in operation, as the series-incandescent plan, it is a very satisfactory one because of its greater reliability, the extinguishing of one lamp through breakage of the filament, or even the burning out of one transformer, not entirely crippling the service.

All the transformers are of a special type made by the General Electric Company for this installation. They are oil-insulated, and have copper shields interposed between the primary and secondary windings. These shields are grounded when the transformers are installed, and form an efficient guard against the high-tension primary currents reaching the secondary coils.

It is interesting to note that while it is often claimed that this construction renders the transformers much more liable to damage by lightning no such difficulty has been experienced in this case, the company finding on the contrary that it has had far less trouble with them in this respect than with any type previously tried. Out of 225 in place only three were damaged during the summer of 1896, and in each case the shields clearly showed that the discharge had been carried off through them to the ground.

In conclusion, attention may again be called to the title of this sketch; a "Modern Central Station" is what it has been attempted to describe, no effort having been made to seek one remarkable for its size or strikingly prominent for its peculiar features. Neither is it contended that the plant is above criticism, but it certainly well illustrates the tendency of modern American central-station practice.

Much credit is due to the president of the Suburban Electric Company, Mr. A. M. Young, and to the general manager, Mr. E. H. Stevens, for embodying in the plant so completely the very latest developments in the central station field; while the latter and Mr. E. R. French, electrical engineer of the station, are to be congratulated upon the excellent results achieved in operation.



FIGS. 10 AND 11.—FRONT AND REAR VIEWS OF SWITCH-BOARD OF ELIZABETH STATION.

THE ELECTRIC LIGHTING OF BRIGHTON, ENGLAND.

BY FRED. BATHURST, A. I. E. E.

THE "Queen" of English watering places, Brighton, can well be called London-super-Mare, for so conveniently is it situated on the Sussex coast, 50 miles due south of London, that it can be reached from that city by the express train service within the hour, or in less time than is required to cross London itself from a northern to a southern suburb. In endeavoring to give a brief description of the electric-lighting features of this popular and fashionable seaside resort, one has, as it were, to look back over the whole of the period of central-station development.

Starting from the year 1881, an interesting history could now be written, outlining the difficulties presented and how perseverance has overcome them, until central-station engineers have attained to their present triumph. This history, if written, would present the progress of electric lighting in Brighton, for in Mr. Arthur Wright—a name now becoming a household word in England—we have an engineer who has in miniature embodied in his own experience all the struggles, trials and resolution which have made electric lighting a success.

In 1881 Messrs. Siemens, one of the few pioneer electrical firms still remaining with us, started on behalf of the Brighton Corporation some arc-lighting experiments on the marine parade.

From this trial of the "new illuminant" the seeds were sown through which the present magnificent municipal enterprise must have its being. On account of the "cost" these trials were destined to remain

experiments, and Brighton waited until a health exhibition brought several competing electricians into the town, each one claiming superiority for his "system" over every other. The enterprise of Messrs. Hammond & Company resulted in their gaining permission to install in the town a small generating plant of 16-arc light capacity for the purpose of giving to the more enterprising tradesmen a brilliant light for illuminating their shop premises. This was in February, 1882, and really formed the first public central station started in England. It was installed in a small shed at the back of Messrs. Reed's iron foundry on Worth Street, within a stone-throw of the site of the present station.

Mr. Arthur Wright was the engineer in charge of the plant, and under his guidance the business increased and street overhead wires were installed to deal with the wants of fresh customers. In the light of what will be made the main point of this paper it is interesting to note the fact that even in this initial period of development Mr. Wright had already ideas as to the proper basis upon which to charge for electrical energy and in the absence of meters to measure the current taken. The price, which had first been arranged on a monthly rental, was with the extension of supply rearranged and based upon the consumption of current, which was measured by the number of carbons burnt in the lamps.

In June, 1883, incandescent lamps, arranged in series, were placed on the high tension arc-light mains, and although these were first charged for upon a fixed rental basis, with the introduction of the electrolytic meter the price was rearranged upon an actual consumption basis. Then came in England the craze of "limited companies," and the business which had hitherto been carried on under the name of "Hammond Electric Light Company" became that of the "Brighton & Hove Electric Company, Limited." The business steadily increased and dividends of 4 per cent. in 1886 and 5 per cent. in 1887 were paid in spite of the fact that the Board of Trade unit (1000 watt-hours) was supplied at an equivalent of 25 to 33 cents per KW-hour. In 1888 the development of electrical knowledge led to a complete change over in the "system" of supply, for the high-tension continuous system was supplanted by the high tension-alternating system with transformers.

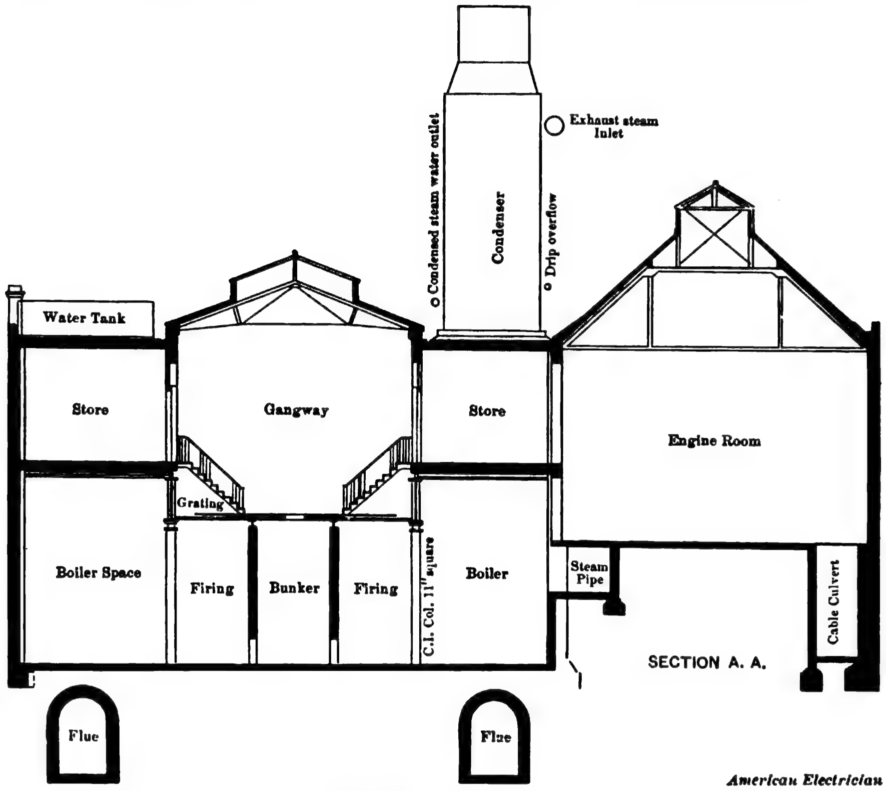


FIG 2.—CROSS-SECTION OF STATION AT A-A.

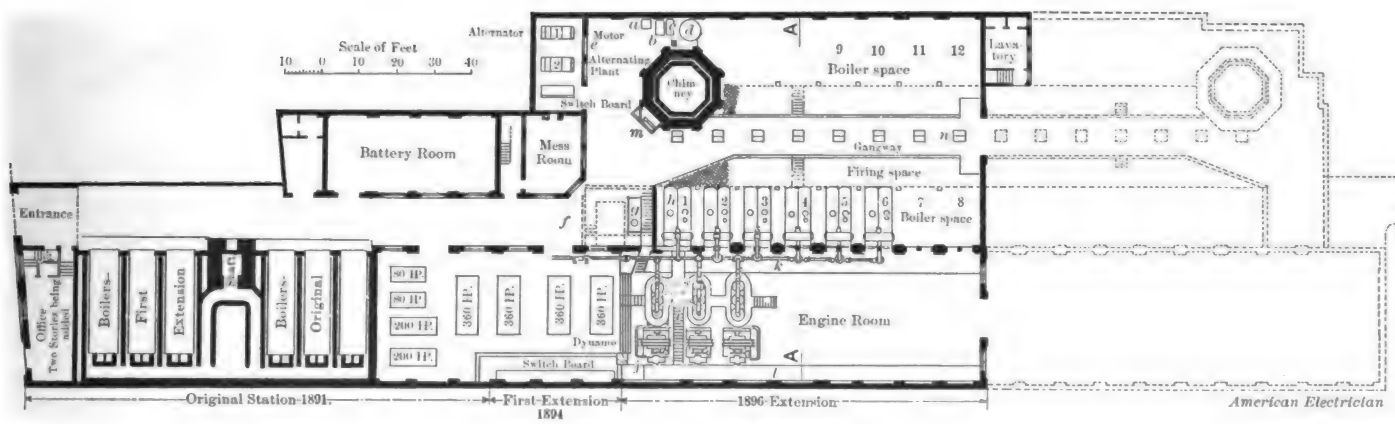


FIG. I.—PLAN OF BRIGHTON STATION.

The change over was effected by installing in different parts of the town storage-battery stations supplied from the high-tension continuous current. At this stage in affairs Mr. Wright temporarily resigned his connection with the electric company. The flexibility of the transformer system assisted further development and very soon it appeared as if the electrical supply business was to become a very lucrative monopoly.

This, however, in democratic England was not to be, for the success of the company had been jealously watched by that august body known as a Town Corporation, and which body, in the nature of English conservatism, had preferred hitherto to stand by and perhaps profit by the experience and work of the private company. In 1889, however, the company applied itself for provisional orders from Parliament to enable it to carry out the duties the Corporation had neglected, but, as usual, the application was opposed by the Corporation, and this body claimed first right in the matter and proceeded to employ a consulting engineer (Mr. Shoolbred) to advise them. Plans were drawn up which led to the erection in September, 1891, of the present electricity works. Then began a struggle for electrical supremacy, which could only end one way. It was the old story of the lion and the lamb, and when, after Mr. Shoolbred's retirement in November, 1891, Mr. Wright was appointed consulting engineer and manager to the Corporation, the "lion" soon got on the outside, for negotiations eventually resulted in the purchase of the old pioneer company's good will by the Corporation and the transfer of their customers to the Corporation mains.

Since 1892, thanks to the helpful Lighting Committee the success of the Corporation's efforts has been indisputable, and the station is each year paying off the cost of its erection and even making a good profit besides, which can go to the reduction of the general district rate. The Corporation Station was first designed as a two-wire tension, continuous-current system (115 volts), but it was early recognized that the whole municipal area could not be supplied eco-

nomically from this one point, and to avoid the necessity of other stations the first engineering change effected was to convert the system into a three-wire one. The general design of the station is clearly shown by Figs. 1 and 2.

FIG. 3.—BATTERY OF LANCASHIRE BOILERS.

As first designed, the boilers and engines were arranged at opposite ends of the long, narrow building, but since the acquisition of more space it has been remodeled so that the boilers and engines lie in parallel lines side by side. The building already completed is indicated by the thick lines, and the enlargements contemplated for the future by dotted lines. Entering through the office or by the gangway and passing into the passage, we find on our left two batteries of three Lancashire boilers (see Figs. 1 and 3), each boiler being of 250 HP. These are used to take the light or steady load of the station because of easy handling and economy in coal consumption. Passing on, upon the left hand we find a small accumulator room, while the engine room lies on the right hand. Opposite to it is the base of the immense octagonal chimney, 200 feet high and 10 feet in diameter, designed for 6000-HP boiler capacity. And further on another battery of boilers (see Fig. 4), Babcock & Wilcox type, each 500 HP capacity. These were chosen for quick steaming and their ability to deal with a sudden heavy load. They give a large HP capacity for a minimum of floor space and can be under steam within ten minutes. The combination of the types, therefore, affords several advantages and presents easy proportionment of boiler power to suit the load. They are fired manually and work at a steam pressure of 180 pounds.

Until the newly discovered coal fields in Kent are developed Brighton remains very badly situated in respect to a coal supply. The coal used in the station has to come from the Welsh coal fields 200 miles away, and costs $5 per ton at the railway station, to which price must be added 20 cents per ton extra for cartage into the station. The carts enter the passageway and dump their load in front of the Lancashire boilers, or proceed on to the passageway grating at the other end, where the coal falls through chutes to the furnace level of the water-tube boilers. Consideration has been given to the difficulty of coal supply, and ample storage provision made in case a coal or railway strike should render it necessary to have on hand a large reserve.

Water is taken from the town mains, fed from artesian wells sunk miles away in the chalky soil of the Sussex Downs. All the water taken by the station is metered and charged up against the station by the town authorities as if it were an ordinary customer. At the station it is passed through a purifier which removes the excess of chalk contained (something like 8 tons of chalk being extracted yearly) into storage and settling tanks.

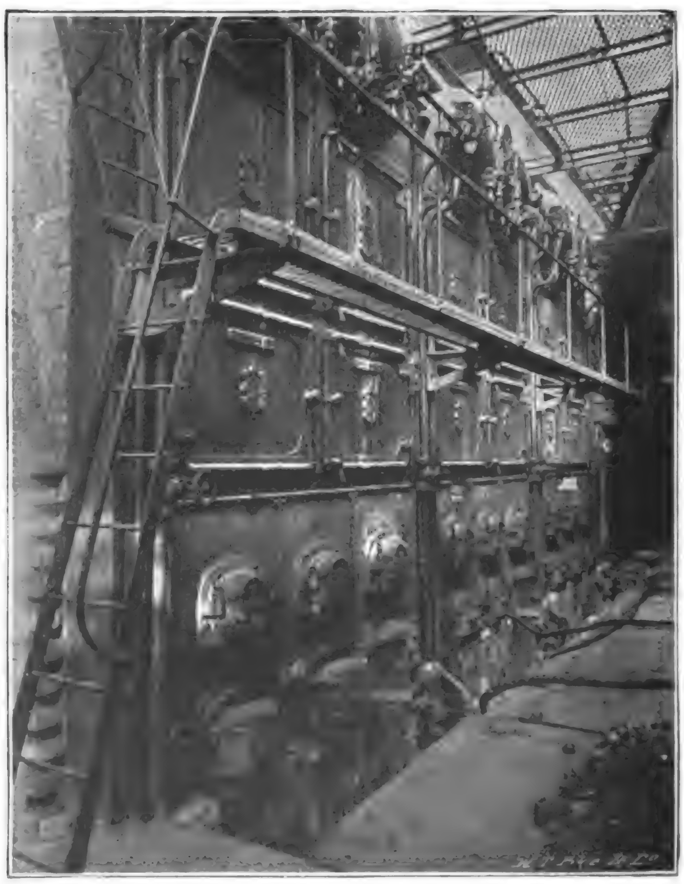


FIG. 4.—BATTERY OF WATER-TUBE BOILERS.

Suction and feed pumps pass the water through an economizer placed in the chimney flues, so that it enters the boilers at a temperature very near boiling point. The boiler-feed pumps and all such equipment (including the ash conveyor which brings the ashes up from below and deposits them in the empty coal carts passing out of the passageway), are driven by electric motors, so as to economize upon the excessive steam consumption of several small engines.

All the station piping, steam, feed or exhaust, is duplicated, and so interconnected as to allow the use of any particular boiler with any engine; or all in unison as desired.

The load the station has at present to meet is equivalent to 70,000 8-CP lamps. The engines in operation are two of 80 HP, two of 200 HP, two of 360 HP and two of 400 HP, while one of 1000 HP is finished erecting and will be running on next winter's load. As shown by Fig. 1, provision has been made for a further equipment of 6000 HP. The demand on the station increases so rapidly each year that it is always in a state of extension and transition, and when it is stated that so far there has never been any serious hitch, and that current has not yet been off the mains by reason of breakdown since the station was started, no further testimony is required as to the engineering ability employed and displayed. A general view of the engine room, which also shows the 10-ton overhead traveling crane, is seen in Fig. 6. The engines (Fig. 6) are by Willans, and of the well-known enclosed triple-expansion type, the crank shaft driving direct on to the armature shaft of the standard bi-polar inverted field type dynamos made by Siemens, Goolden & Crompton. The 1000-HP machine being installed is designed as a 4-pole dynamo.

The compactness and comparative silence of the engines give to the station an unexpected quietness and simplicity of appearance that at once commends itself favorably to the visitor, who is also further impressed when he is told that the station is also equipped for an alternating-current supply.

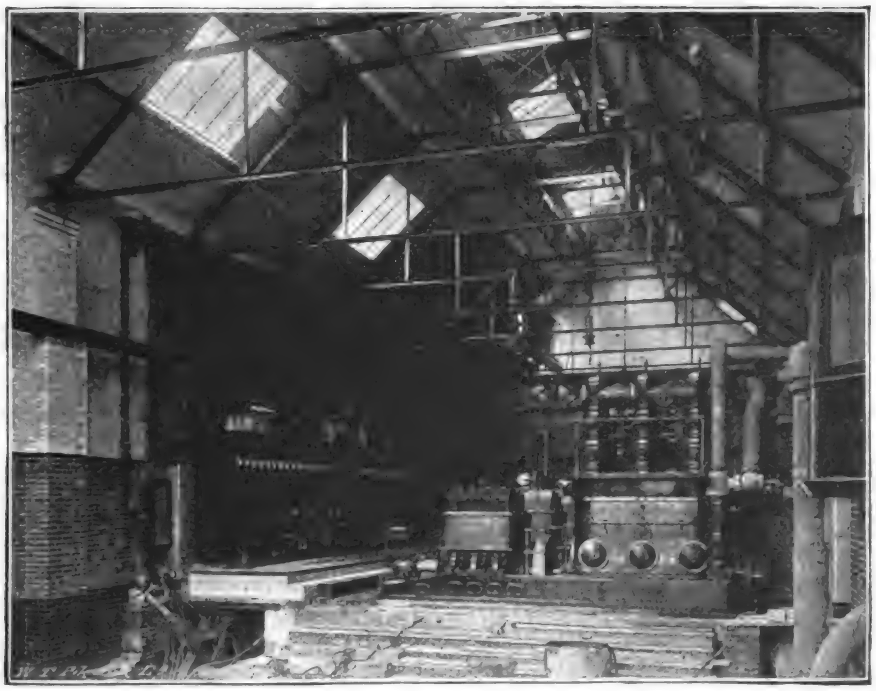


FIG. 5.—GENERAL VIEW OF SWITCH-BOARD AND ENGINE ROOM.

Mr. Wright was one of the first, if not the first, engineers in England to confirm Mr. Ward Leonard's recognition of the true field for an alternating-current electrical supply—that of developing the business for a continuous-current system. Finding that his three-wire low tension system (115 volts) could not economically open up the outlying residential districts of the town, the plan has been adopted of first developing such a district by means of the more flexible alternating system, and when a payable load has been obtained changing it over onto the main system.

For this purpose there has been installed in a small room a high-tension plant consisting of two small alternators, each of 35-KW capacity, and driven direct by continuous-current motors (700 r. p. m.) connected to the main system. This little plant, complete in itself, is, as it were, boxed away in a cupboard and left to take care of itself. In the daytime, when the station load is low and the distributing system lightly loaded, a residential district can be switched over onto the regular service, but as the load increases and the mains become taxed to their full capacity the alternating plant is started up and a current supply at 2000 volts sent along special feeders to transforming points, and the outside district switched over to the alternating system. In this way the district gains a day and night service, while involving a minimum expenditure for copper, plant and maintenance. About 100 KW is expected to be the limit of the alternating-current apparatus which will ever be required, its use being merely to bring each part of the town into the electrical fold.

The station is also provided with a storage battery. These cells were put in during the early days when it did not pay to keep the engines running on the lightest load, but they have long passed that use, and the battery (144 cells) now does service as the voltage regulator of the station, although it could also be useful in case of any temporary hitch or disorganization. The normal current capacity of the battery is 150 amperes.

The regulation and adjustment of the above plant is effected from the switchboard, a general view of which in relation to the engines is shown by Fig. 5, and a more detailed view of the board itself in Fig. 7. Its general design is that of a "plug" board, the street feeders and the leads from the dynamo being brought to massive copper bars, the former on the front and the latter at the back, connections being made between any of them by long solid copper plugs. These plugs are removable by the attendant, who can raise or lower the voltage on any machine, and "plug" a higher or lower voltage on to any feeding point requiring regulation.

All the machines except one are wound for 240 volts, and run across the outer conductors of the three-wire system. The adjusting machine (80 HP) has a doubly-wound armature for 120 volts on either side, and is connected up on each side of the central. Its regulation is accomplished either by changing the resistance of its fields, by a series German silver resistance in either armature circuit or by altering the speed. With the largest load on the station, say, 9000-10,000 amperes output, the greatest loss of balance on the system is never more than 150 amperes; in fact, the arrangement of the load outside on the mains is so good that 100 amperes is the average maximum current the neutral is ever called upon to carry. All customers requiring more than 30 amperes are wired on to the three-wires, and the load arranged to fall equally on positive and negative sides. Out of a total of 1400 consumers 100 are across the system. The exactness of the method adopted for metering and measuring the current required by each customer is the distinctive feature of the Brighton station.

The average day load of the station is equivalent to 3000 8-CP lamps, which, looking to the small amount of manufacturing

FIG. 6.—GENERAL VIEW OF WILLANS TRIPLE-EXPANSION ENGINES.

done in the town, must represent the lighting of basements and dark passages, although of the total load connected, equivalent to 67,000 8-CP lamps, there are included some 215 arc lamps, 564 incandescent street lamps, and 60 motors, the

largest of which—5-HP capacity—are employed in driving printing presses.

The switchboard is fitted with large-dial main voltmeters, which can easily be read at a distance, and with Kelvin, Weston and Evershed ammeters and voltmeters, the former arranged on the station machines, the latter on the feeders. Fuses, magnetic cut-outs, plug and lever switches, with field-regulator contact switches, complete the usual equipment of this well-designed board.

A diagrammatic plan of the town mains is given in Fig. 8, in which the position of the station is marked by a square and the various feeding points are indicated—the boxes for continuous current by a black dot, while those in which transformers are provided for the alternating current are designated by a circle. The plan shows clearly how the outlying district above the town proper is reached by an alternating current service.

Each consumer on the mains is also indicated by a short line at right angles so that their relative position and density can also be seen. When mains are to be laid down in a new street an estimate is made of the amperage per yard run which will be required, this being based upon experience in other parts of the town.

The length of the main between the two nearest feeding points is then taken and such a weight of copper calculated as will allow a drop in voltage of more than 2½ per cent. at the point half way between the boxes. In Brighton 4 amperes per yard is the greatest density experienced.

The feeders (which carry 230 volts) are calculated for a maximum drop of 20 per cent. when fully loaded, but as full load comes on to them the station voltage is raised so that the feeding points are kept at 118 volts, which means that the customers nearest the boxes get a slightly higher voltage than they pay for, while those most distant secure a perfectly constant voltage under all conditions of load. The mains are connected together as much as possible in rings.

The plan followed for feeding points is to try and arrange them about a half a mile apart, as local conditions permit, and in the case of the load or a main increasing beyond that anticipated, to lay an extra feeder as near the middle point of the main as can be. The largest feeder yet put in is 1¼ miles in length. Mains are calculated for 1000 amperes and feeders for 1500 amperes per square in section.

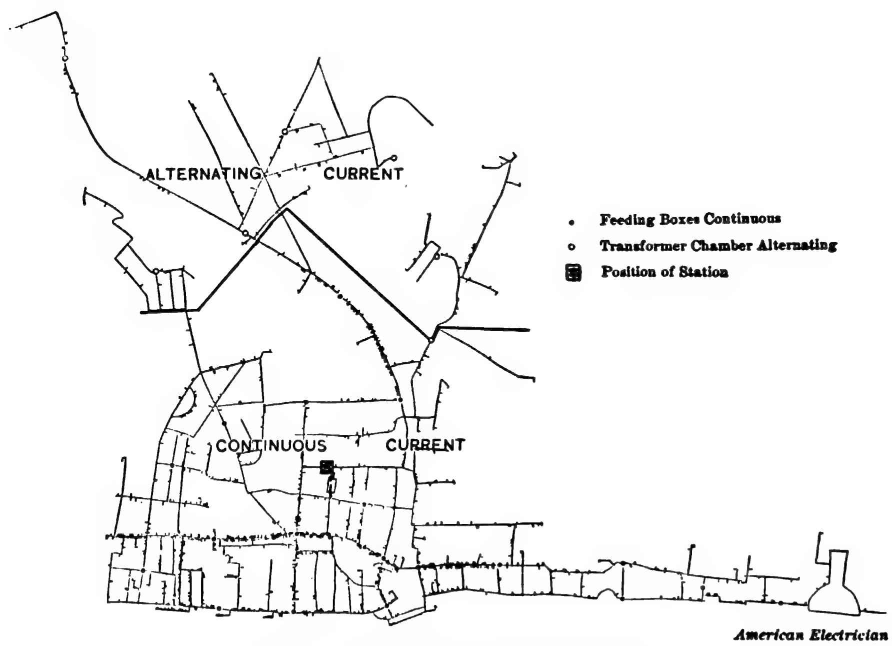


FIG. 8.—MAP OF DISTRIBUTING CIRCUITS.

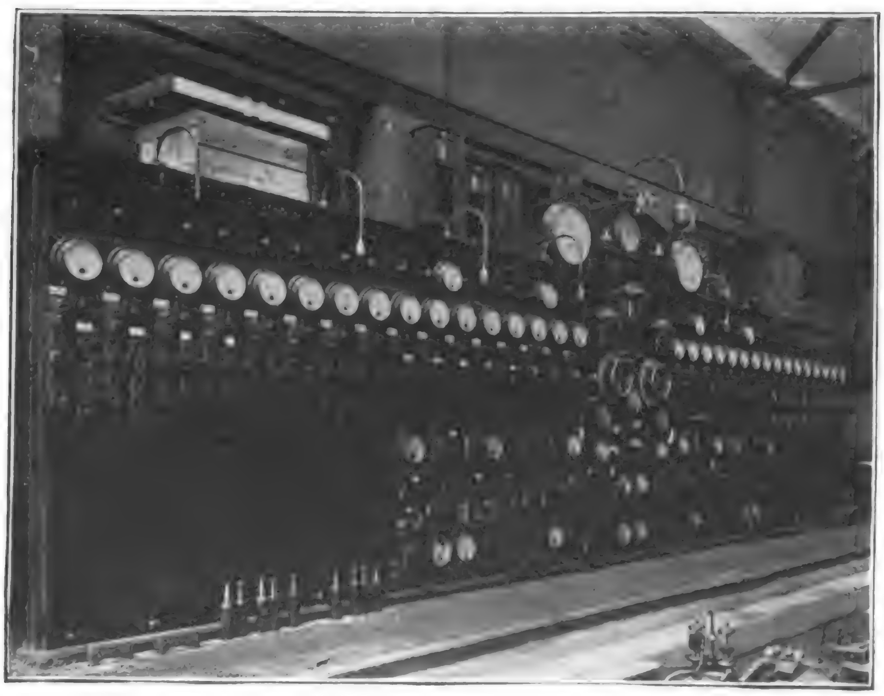


FIG. 7.—GENERAL VIEW OF SWITCH-BOARD.

Owing to the exact manner in which the current as taken by each customer is determined, it is the practice in Brighton to provide a neutral which is only one-fifth or one-sixth the weight of either outer wire. Concentric conductors are provided for the alternating and the ordinary separate-stranded conductors for the continuous system. All cables are steel-taper armored and placed direct in the earth, a line of bricks being laid above them to indicate their presence to those excavating afterward. House connections are made in ordinary cast-iron jointing boxes filled in with bitumen compound.

In the above description endeavor has been made to include the main engineering points of interest to central station engineers, but the characteristic point of the station rests more in the principles upon which its business is catered for than upon its design and equipment. It has recently been a subject of inquiry and discussion in the London newspapers as to how electric lighting in a town like Brighton can be supplied cheaper than in a large city like London? To the non-technical this question is still enigmatical, but to those who have the advantage of being able to look closer into the matter it becomes evident that other companies could achieve the same results providing they pursued the same policy.

At present most electric-light supply companies, following the practice already made familiar to us by the old-established gas companies—who charge for light by the number of cubic feet of gas consumed at so much per 1000 cubic feet—have adopted a "fixed charge per unit" as the means by which the cost of electricity supplied is determined. Granting that many central stations have been installed with the best engineering skill obtainable, the main idea which has governed the central station manager has been to secure as many customers as possible, in the belief that every unit he sells at the fixed price per unit brings in its profit and the greater must be the annual profit for the station.

Mr. Arthur Wright very early recognized that the financial success of an electric station did not rest so much with the number of customers connected as upon their particular habits and the time they required light. It was Dr. Hopkinson who first pointed out that the cost of supplying electricity can be correctly defined at so much

per unit, unless the rate of supplying that unit be also stated, and showed that the cost depends much more on the greatest rate at which electricity is to be supplied than it does on the amount actually supplied. The truth of the statement is beginning to force itself upon station engineers, and they recognize that the conditions of production which hold in respect to the manufacture of gas are very different to those obtaining for electricity, because with gas the plant can be kept running steadily during the whole 24 hours of the day, generating either in large or small quantities into storage reservoirs, so as to meet the total consumption; but with electricity, on the other hand, a large amount of capital must be expended to provide beforehand and hold ready the generating plant necessary to meet the maximum requirements of all the consumers at any given moment.

The standing charges in respect to any electricity works may be 85 per cent. of the total expenditure required for the load, as against perhaps 25 per cent. in respect to a gas works. In an electricity works kept continuously running the cost of production in respect to fuel, etc., consumed to produce the energy need not be more than 15 per cent. of the total expenditure. Central station engineers have devoted much skill and experience to the reduction of the running costs of their works, but have comparatively neglected the more important question of how to diminish the much greater standing costs involved in electricity supply. Large but short-time consumers need not be profitable ones, whereas the small but long-time consumers can become the only class worth catering to. Electricity without storage facility cannot compete in price with gas when the light is only re-

TABLE I. AVERAGE COST AND CHARGES.

SHOWING THE RELATIVE PROFITABLENESS OF LONG-HOUR CONSUMERS.

No. of hours demand is used per annum.	Average number of hours demand is used per day.	Average time of extinguishing the light throughout the year.	Average charge in cents for each kilowatt hour consumed (14 cents for first KW hour, and 3 cents afterward.	Equivalent charge in terms of 1,000 cu. ft. of Brighton gas (7 KW hours to cu. ft. of gas).	Annual charge for each 8-CP lamp demanded	Annual charge for each 8-CP lamp demanded in terms of Brighton gas at 67 cents.	Per cent. of 3 units to the total number consumed per annum.	Loss or profit in cents per unit consumed.
182.5	½	6.30	7.14	$1.00	.72	.48	......	18 Loss
365	1	7	7.14	1.00	$1.45	.97	......	2.8 "
547.5	1½	7.30	or nearly 10⅓	.75 †	1.61	$1.46	33	1.28 "
730	2	8	" 8½	.61½	1.77	1.96	50	.3 "
912.5	2½	8.30	" 7½	.54	1.91	2.45	60	......
1095	3	9	" 6⅔	.47½	2.08	2.93	66.75	.2 Profit
1277.5	3½	9.30	" 6⅛	.44½	2.26	3.48	71.5	.6 "
1460	4	10	" 5⅞	.41	2.38	3.93	75	.74 "
1642.5	4½	10.30	" 5½	.39	2.53	4.43	78	.8 "
1825	5	11	" 5⅓	.37	2.70	4.93	80	.9 "
2007.5	5½	11.30	" 5	.36	2.86	5.43	82	1.0 "
2190	6	12	" 4⅞	.34½	3.01	5.93	83.5	1.02 "
2555	7	1	" 4½	.33	3.32	6.93	86	1.16 "
2920	8	2	" 4⅜	.32	3.70	7.93	87.5	1.2 "
4015	11	Dawn	" 4	.29	4.58	10.81	90.9	1.44 "
8760	24	continually	" 3½	.25	8.39	23.54	96	1.58 "

† Electricity in Brighton becomes cheaper than gas after the first hour and a half's consumption.

TABLE II. AVERAGE CHARGES.

SHOWING HOW THE COST OF ELECTRICITY (BY THE BRIGHTON REBATE SYSTEM) DIMINISHES WITH THE LENGTHENED DAILY USE OF THE LIGHT.

Class of rooms and premises in which the lamps are used.	Average number of hours the lamps are used per day.	Total number of hours the lamps are used per annum.	Usual time of extinguishing lamps lighted at dusk.	Average rate charged per unit consumed during the year. 14 cents for first unit, 3 cents afterward.	Equivalent cost of gas used in ordinary burners, per thousand cubic feet.	Annual cost of electric and ordinary gas-burners giving 8 CP.		Amount saved per annum on each 8-CP lamp by use of electricity, exclusive of saving in redecorating, &c.	Time in which the cost of fitting up the electric light will be repaid by the saving effected, due to its lesser cost and extreme cleanliness.
						Electric lamp, including renewals.	Ordinary gas burner with gas at 67 cents per 1,000 cubic feet.		
Offices, early-closing shops, and occasionally used rooms (100 approx.).	1	365	7 p. m.	14c.	$1.02	$1.45	$0.97	....	......
Shop windows.................	2	730	8 "	About 8½c.	.62	2.02	1.95	....	......
Interiors of shops (600 approx.)	3	1,095	9 "	" 6⅔c.	.47	2.33	2.93	$0.60	2½ years.
Sitting-rooms, halls, kitchens, basements, and late-closing shops (300 approx.).	4	1,460	10 "	" 5½c.	.41	2.77	3.93	1.16	2 "
Hotels, restaurants and public houses (100 approx.).....	5	1,825	11 "	" 5½c.	.37	3.20	4.91	1.70	19 months.
Clubs and billiard rooms (20 approx.).....................	6	2,190	12 "	" 5c.	.35	3.52	5.89	2.37	16 "
	7	2,555	1 a. m.	" 4½c.	.33	3.95	6.87	2.91	14 "
	8	2,920	2 "	" 4⅜c.	.33	4.45	7.87	3.41	12 "
Outside lamps, dark business premises and basements.....................	11	4,015	Dawn, or used all day long.	" 4c.	.29	5.58	10.81	5.22	9 "
	24	8,760	Continually used day and night.	" 3½c.	.25	10.64	23.54	12.89	5 "

quired for short periods, such as an hour a day, but when charged for upon a correct basis it can readily compete in the lighting field for that desirable class of customers which requires artificial light for several hours in a day. Table I. shows the relative profitableness of short- and long-hour customers.

In Brighton this third-class type of consumer already gets his illumination from electricity at a lower cost than he can from

ARTHUR WRIGHT, ESQ.

gas, and as a consequence electricity is used far more generally per head of population than in any other town in the United Kingdom. This result has been achieved by the adoption of a "sliding scale" method of charging for the current supplied, while the success of the method can be summed up in the two words "demand indicator," the instrument designed by Mr. Wright

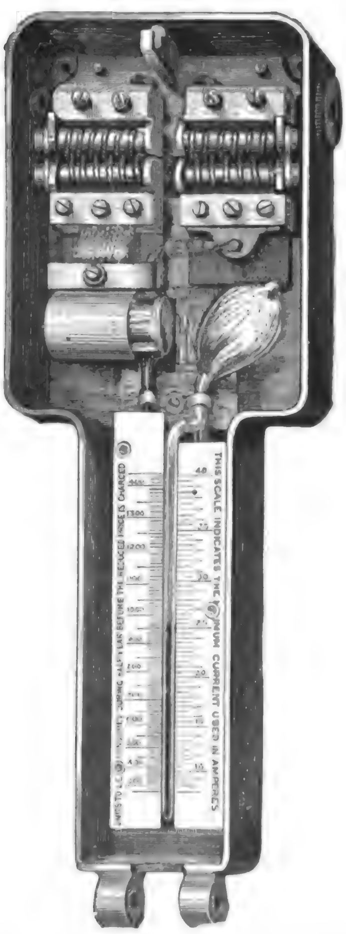


FIG. 9.—WRIGHT DEMAND INDICATOR.

and by which the principle is carried into practice.

The "Brighton method" consists in charging two rates per unit supplied; the first rate is calculated on the basis of covering the capital and standing charges of the electricity plant and equipment, if the consumer takes the maximum demand for an average of, say, one hour per day only. After this, having covered his due share of the expense of equipment, the current he requires in excess is supplied at a lower rate, one which covers the cost of production only. This means that customers who use the light for a short time only, pay a higher rate than those who use it for a long time. The charges are 14 cents and 8 cents per unit respectively. The first charge of 14 cents cannot be reduced until in the course of years the profits made have paid for the station itself, but the second charge for units after the first hour can be reduced as the demand on the station increases. In Brighton it has been 7 cents in 1893 and 1894, 4 cents in 1895 and 1896, and now 3 cents for the year 1897. In Table II. the prices have been worked out so that one can see at a glance the average price per unit a customer pays for a certain "demand" per annum, and indicates very clearly when a long-time consumer gets his light cheaper than gas, and also becomes a source of profit to the station. Unless he burns his demand for 2½ hours a day, gas is cheaper for him, but after that electricity rapidly becomes the cheaper, until with 5½ hours a day and at an average rate of 5 cents per unit the station can make 1 cent per unit or 20 per cent. profit out of him.

The "demand indicator" (Fig. 9), the instrument by means of which the charge to be made is determined, is a registering thermal ammeter, which is connected in series with the consumer's ordinary meter, and so designed that it records the maximum current used by the consumer.

In operation it may be likened to a maximum thermometer, but its construction is such that it takes fully a quarter of an hour to record, so that the consumer shall not suffer by lighting a few extra lamps for the period of a few minutes during the time of his greatest demand. It consists of a hermetically sealed, U-shaped tube of glass, partly filled with colored sulphuric acid. A bulb is blown on the arm on the left side, and has one or more turns of a platinoid strip wound around it, and through which the main current of the house passes. On the right arm another bulb of peculiar shape is blown, and is provided with a long, thin tube.

When a current passes through the platinoid strip it becomes heated and causes the air in the bulb to expand in proportion to the heat developed. The liquid is forced down the left arm and up into the right-hand one until it enters the right bulb and can overflow into the thin index tube, which acts as a trap well and retains all the liquid which is forced over into it. This index tube is calibrated so that the height of the liquid found in the tube indicates the maximum current which has passed through the meter. The U-tube is mounted on a hinged plate, so that when the iron case is opened the liquid can be caused to run back from the index tube into its original position; the index tube is thus cleared at each visit of the inspector and left for the next indication.

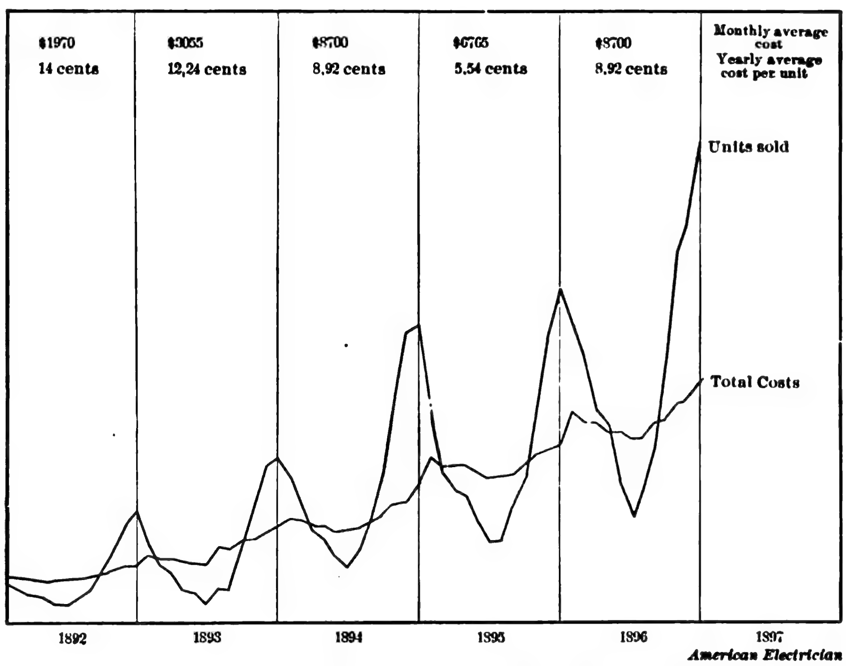


FIG. 10.—CURVES OF TOTAL MONTHLY COST AND UNITS SOLD.

The instrument is inspected every month and the average of the readings obtained taken as representing the customer's average demand. The supply is measured by the ordinary meter (it might be mentioned that Ferranti meters are used for continuous-current circuits and the Thomson meter where circuits may be both continuous and alternating), and the smaller the demand reading and the greater the total units registered, the lower the average price works out. It is evident, too, that the charge to be made can be worked out by any customer who knows his multiplication table and can read off what his maximum current demand has been. The cost of equipping an ordinary station of 500 to 1,000 KW output has been approximately estimated at about $11 to $12 per customer.

That the Brighton system is commercially sound and has much to recommend it is proved by the fact that recently some thirty other towns throughout Great Britain have

either already adopted it or are considering its adoption, while its unqualified success in the town of its inception can perhaps be proved by giving some facts and figures gained from Mr. Wright's inexhaustible store.

While the method of charging is designed to provide an equitable tariff by day or night, either for lamps or motor load and large or small consumer by the payment of a rate per unit based upon the actual call on the station, it has been the policy of the corporation to cater to the small class consumer who burns his lights, etc., for lengthened periods; the various consumers on the circuits, and their relative size are shown in Tables II. and III., in which it will be noted that 44 per cent. of them require less than 6 amperes and 30 per cent. less than 12 amperes each, so that 74 per cent of the station load is made up by customers having less than 12 amperes each, and in spite of which its earning capacity is beyond question or reproach.

As an illustration, however, of the discrimination exercised even in respect to the third-class consumers, it might be well to mention the case of the Brighton workhouse. Probably few station managers would hesitate to take at once a building in which 2,000 lamps are fitted, but this was done here because a critical examination of the records of their gas consumption clearly proved that each gas jet was lighted for less than an hour a day, so that if connected it would always be charged at the 14 cents per unit rate and be a burden to the rest of the plant.

Out of 1,400 customers there are only some 140 who are at present not benefiting by the rebate system and who are therefore non-paying customers It is found that it costs $1,200 per year to be ready to supply them (worked out on the basis that each 8-CP lamp that requires to be simultaneously lighted costs $2 for plant, etc.), whereas their aggregate bills only come to $205. It is proposed to circumvent this condition by providing that a suitable minimum charge per year be enforced in respect to every one connected, whether he uses current or not.

A further very interesting result is shown in Fig. 10, in which the total monthly expenditure (including all charges for production, interest on capital, etc.) is plotted in the form of a curve (the heavy line) and the corresponding units sold plotted alongside. If the cost of the units produced depended directly upon the number sold these curves should accord with one another; they show, however, how very slightly the total expenditure varies during the different months of the year, although the output or sale of units varies very greatly with the different months. In fact, the expenditure of a year varies with the *maximum* load which the station has to be prepared to meet in each year rather than with the total number of units sold in any month during the year.

Gas at Brighton costs 67 cents per 1000 feet, and calculation shows that, light for light, 7 units of electrical energy are equivalent to 1000 cubic feet of gas. The gas company is feeling the competition, for its total revenue last year of $650,000 was less than was anticipated by $75,000, which reduction it is endeavoring to meet by economizing in the cost of production (using the latest methods of manufacture) and by pushing the use of incandescent gas burners. The electric station, however, has got beyond the pale of competition, for less than one-quarter per cent. of its customers discontinue the use of current and return to gas.

The substantial financial progress made by the electric station in the years it has been under municipal control (because since that time full records in every department have been obtainable) is indicated by the net profits remaining after paying the capital charges of 5½ per cent., as follows: $60 in 1892, with an average charge of 14 cents per unit; $1,500 in 1893, with an average charge of 12 cents; $25,475 in 1894, with an average charge of 12 cents; $6180 in 1895, with an average charge of 9½ cents, which reduction was equivalent to giving to the consumers a further $30,000 profit on the old rate); and finally $29,400 in 1896, with an average charge of 9 cents per unit. This latter figure would represent a possible dividend at 8 per cent. for an ordinary company, had it been working with a municipal generosity in respect to reductions in the price of the unit.

TABLE III.

SHOWING THE NUMBER OF CONSUMERS IN BRIGHTON, AND THE RELATIVE DEMANDS FOR ELECTRICITY.

AMPERES DEMANDED.	NUMBER OF CUSTOMERS.	PER CENT. OF TOTAL NUMBER CONNECTED.
0 to 5	652	44.55*
5 to 10	440	30.05†
10 to 15	156	10.65
15 to 20	88	6.01
20 to 30	70	4.78
30 to 40	27	1.84
40 to 50	11	.75
50 to 75	9	.61
75 to 100	5	.34
100 to 200	6	.41

* The demand of 44.55 per cent. is less than 5 per cent. of output.

† The demand of 74.60 per cent. is less than 10 per cent. of output.

The kilowatt hours sold are 156,000 in 1892; 286,000 in 1893; 583,000 in 1894; 867,000 in 1895, and 1,388,000 in 1896. Of the 1896 output 300,000 units were sold from dawn to dusk and out of the net profit made of $29,400 it is estimated that these 300,000 day units produced nearly $10,000, thus showing how profitable it is to cultivate the day load.

The highest loads per year, in amperes recorded, were: In 1892, 1940; in 1893, 3,200; in 1894, 5600; in 1895, 7190, and in 1896, 10,620—which figures show the call the plant had to be ready to supply. If we divide these quantities respectively into the kilowatt hours supplied, we get figures which enable us to compare the increased sale per HP call on the station; these come out at 83, 89, 104, 121, 138 respectively, so that, comparing the year 1896 with 1892 (138 with 83), we see that the electrical energy sold for each HP required at the station has improved 70 per cent., which implies that had the nature of the load not improved it would have been necessary to provide 70 per cent. more plant capacity in the last year than was actually provided.

The sale of electricity in 1896 over that in 1895 was also increased by 50 per cent. That is, in the fifth year of operation it is apparent that the final saturation point is in no respect reached. The above two facts can testify more clearly and telling as to the merit of the business policy being pursued at this station, so that it will only be necessary to conclude with a brief analysis of the 1896 accounts and costs as extracted from *Lightning's* well-known tables:

ACCOUNTS.

Capital expended up to Dec. 31, 1896	$893,405
Revenue	129,075
Total revenue	132,635
Total costs	59,065
Gross profit before setting aside instalments for interest and depreciation and sinking fund	73,570
Percentage of costs to revenue	44 per cent.
Financial result after covering all charges and providing for interest and sinking fund; surplus	$29,150
Number of 8-CP lamps connected, including arcs, incandescents and motors	66,638
Number of units sold	1,388,821

Made up from:	Private lighting.	Private lighting.	Total.
Sold at 14c. per unit.	478.126	29,176	507,302
" 6c. "	648,875	232,644	881,519
Totals	1,127,001	261,820	1,388,821

Units sold per lamp, connections during year being averaged	24
Revenue per lamp (connection being averaged per year)	$2.18
Price charged—Private lighting	14c. and 6c.
" " Power and heat	14c. and 6c.
Average price obtained—Private lighting	9.38c.
" " Public lighting	6.88c.

COSTS.

Generation and distribution:		Per unit.
Coal and other fuel, including cartage	$19,920	1.38c.
Oil, waste, water, etc	3,020	.20c.
Wages of workmen	9,935	.70c.
Repairs and maintenance of entire plant	8,725	.60c.
	$41,650	2.88c.
Works costs:		
General costs—rent, rates and taxes	$6,110	.42c.
All management expenses	11,305	.78c.
Total costs	$59,065	6.96c.

Preece As a Worker.

In a recent interview Mr. Herbert Laws Webb quoted the following answer of Preece in reply to a query as to how he managed to accomplish so much work as he is known to do in one day. "Well," he replied, "I always go to bed regularly at 11 o'clock at night and I always awake regularly at 4 o'clock in the morning. Before I gave up smoking I was always drowsy on awaking. I stopped smoking seven or eight years ago and now I wake instantly and am ready for work. I sit up in bed and put in from four to seven hours at whatever I have in hand. It is a splendid way of adding 40 per cent. to the working day." "Whatever he has in hand" may be the process of a new invention, a monograph on some scientific subject, or an argument on ocean telephony. Nearly all his original papers were written in this manner. But when he goes to the post office he endeavors to forget his early morning work for the time being at least. The evening is generally put in in lecturing or at the meeting of some scientific society.

CENTRAL STATION OF ROUEN, FRANCE.

BY JULES LAFFARGUE.

IN consequence of its special features, as well as from the good results it has given, the electrical station of Rouen is one of the most notable and interesting stations in France.

Rouen is an industrial city of about 110,000 inhabitants, divided into two parts by the River Seine. It is situated a short distance from Paris—two hours by railway.

The first attempts at electric lighting were made in 1888, but it was not until 1893 that the Société Normande d'Electricité really definitely took up the matter and obtained from the city of Rouen a concession for twenty years. A new contract for fifty years has recently been signed, and the Société Normande has been enabled to put in a fine installation. This company kindly permitted the writer to visit the station in the interests of the American Electrician, and to take the accompanying views, showing details of the installation.

System of Distribution.—The distribution is effected by two different systems. For the districts situated within a radius of a half mile around the station on the right bank of the Seine, the distribution is carried out directly by feeders and on the three-wire system. But for the more remote parts, and especially for the supply of the left bank of the river, it has been necessary to resort to other means. At Saint-Sever, on the left bank, a sub-station has been built which is fed by alternating currents. For this purpose an Alioth commutator dynamo, placed in the central station and to be mentioned further on, produces an alternating current of 120 volts. This current is brought up to 2000 volts by a transformer and transmitted to the sub-station by underground conductors, where it is again transformed into a continuous current for distribution within a radius somewhat greater than a quarter of a mile. By means of several sub-stations similar to the one referred to, current is distributed among the more distant quarters of the city.

We shall now examine successively: 1. The station. 2. The distributing system. 3. The sub-stations.

Situation.—The station is situated nearly in the center of the city, at 26 rue aux Ours, in an old church, of which the different parts have been utilized for the installation of the engines and dynamos.

Fig. 5 gives the general plan of the central station, which will be described in detail. In following the rue aux Ours and then passing along a lane leading to the station, we find ourselves first in the large engine room. At the right are the boilers, and a

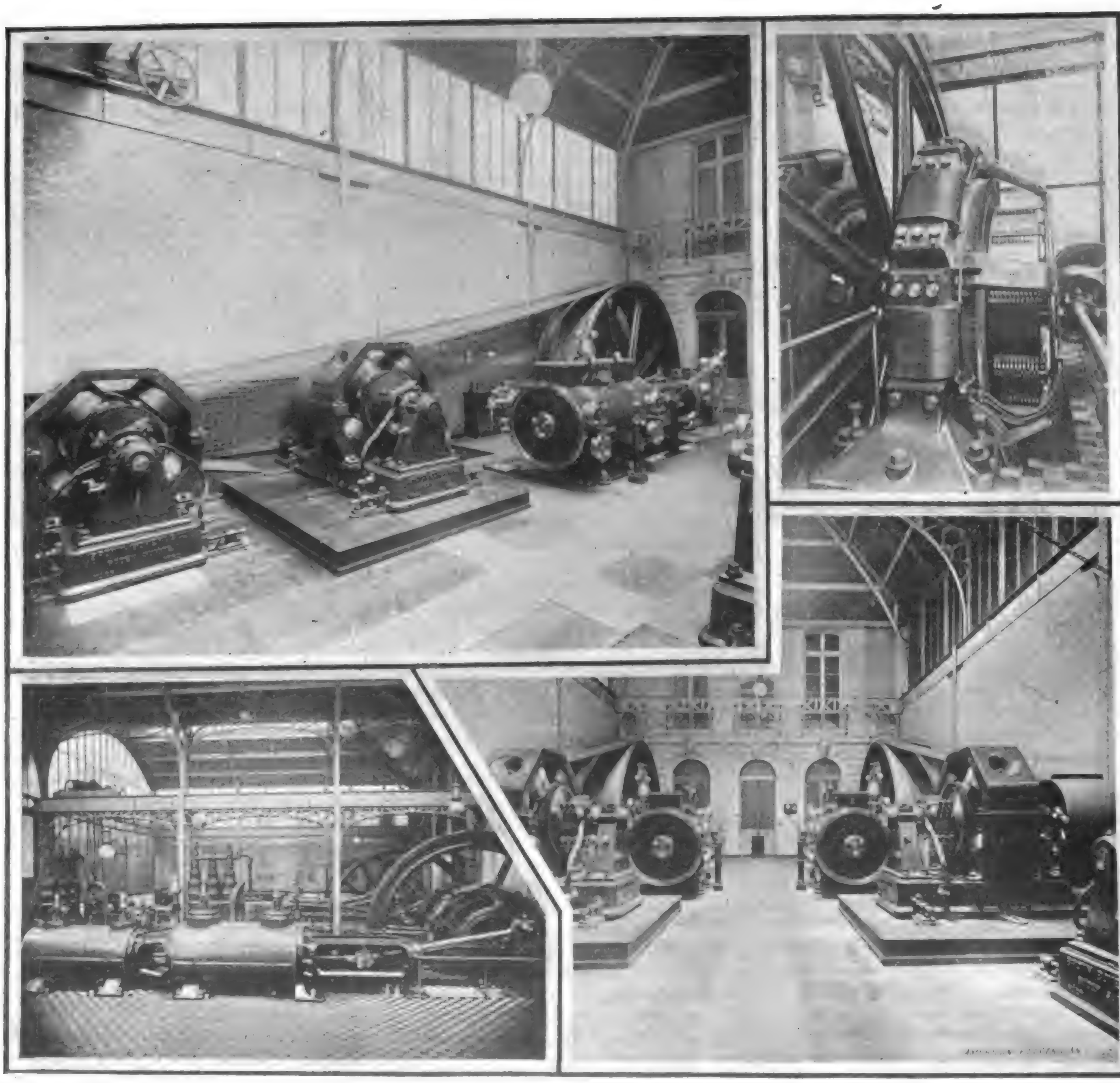


FIG. 1.—BROWN DYNAMOS.
FIG. 2.—1000-HP ENGINE AND THURY DYNAMO.
FIG. 3.—DETAILS OF THURY DYNAMO.
FIG. 4.—FARCOT ENGINES AND BROWN DYNAMOS.

VIEWS IN GENERATING ROOM, ROUEN STATION.

i ttle in front is placed the switch-board for continuous currents; to the left and surrounding the whole are the storerooms, the laboratory, the workshops and the offices.

Boilers.—The boilers, which are eight in number, are of the Niclausse type, and each can furnish 4400 pounds of steam per hour (equivalent to 150 HP) at a pressure of 150 pounds per square inch. These boilers aie multi-tubular, with a steam reservoir at their upper portion; and, in order to obtain a greater reserve, the capacity of the reservoir has been doubled in this case. The chimney of the station has been built for thirty boilers; it has a height of 215 feet and an outer diameter of 6½ feet at the top.

The draught of each boiler can be separately regulated by a damper, and there is also a general damper. Fig. 6 gives a general view of the installation of the boilers. In the plan of Fig. 5 we find at *S* the storeroom for coal, at *N* a heater and purifier of the Chevallet system, which receives the exhaust steam from the feed pumps and is designed to heat the feed-water and at the same time to precipitate the lime-salt.

The boilers are divided into two sets by the arrangement of the steam piping, which supplies either of the sets of steam engines. On one set of boilers which, as we shall see later, supplies the Farcot engines, reducing valves have been fitted which reduce the pressure from 155 to 90 pounds per square inch.

The steam pipes, which are rather long, are connected at different points with the separators, which also discharge into the purifiers.

Steam Engines and Dynamos.—The steam engines and dynamos used at the station may be divided into three distinct groups: 1. The group of Farcot engines and Brown dynamos; 2. The group of Carels engines and Thury dynamos; 3. The group of Willans engines and Alioth dynamos.

1. The group of Farcot engines and Brown dynamos is shown at *A* in the general plan of Fig. 5. It is composed of two single-cylinder, horizontal Farcot engines of the Corliss type, of 400 to 500 HP at a pressure of 95 pounds per square inch and a speed of 60 revolutions per minute. Each steam engine is belted from two fly-wheels to two Brown dynamos giving a continuous current of 144 kilowatts. The dynamos have four poles and furnish 1200 amperes at 120 volts and 320 revolutions per minute. At 350 revolutions per minute the same dynamos generate a voltage of 180 for the charge of a battery of 70 accumulators of 900 amperes. This variation of speed is obtained by a simple adjustment of the steam-engine governor.

Fig. 4 gives an end view of the Farcot steam engines which run the Brown dynamos, and Fig. 1 shows these latter machines. The two dynamos of each group are electrically coupled on the three-wire system.

2. The group of Carels engines and Thury dynamos will be found at *B* (Fig. 5). It is formed of two Carels steam engines of the Sulzer system, horizontal and with two cylinders in tandem. Each engine furnishes 800-brake HP, or 1000 indicated HP, at a pressure of 110 pounds per square inch, and at a speed of 70 revolutions per minute. At 75 revolutions and at a pressure of 140 pounds the

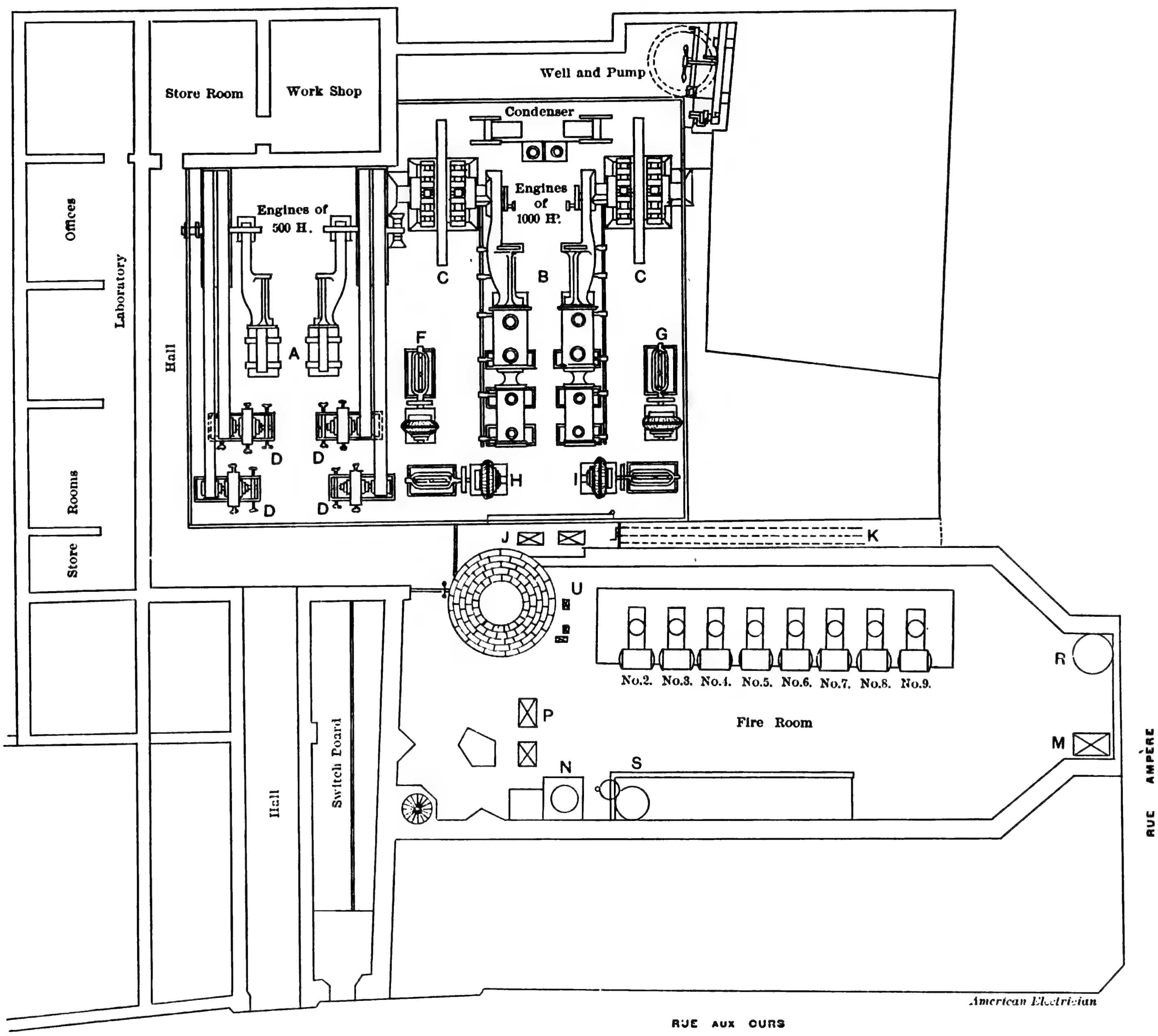


FIG. 5.—GENERAL PLAN OF ROUEN STATION.

engine furnishes more than 1000 net HP. Each engine is designed to be run condensing or non-condensing.

On each side of the shaft each engine is direct-connected with a Thury dynamo, *C*, with ten poles and with carbon brushes, giving 2050 amperes at 125 volts. The two dynamos of each engine can be electrically coupled for three-wire work at 250 volts.

Fig. 2 gives a general view of a 1000-HP engine, and Fig. 3 shows the details of the ten-pole direct-connected Thury dynamo.

2000 volts. Fig. 7 gives a view of a complete Willans-Alioth group at the right, in front of the alternating current switch-board, which will be referred to later.

Before going further, we would call attention to the great interest presented by the employment of commutator dynamos which can furnish at will either a continuous or an alternating current, as may be required. In the present case these sets of 200 HP each are sufficient to supply the general system, assure the charging of the

FIG. 6.—BOILER ROOM.

positive. The station contained formerly four batteries similar to those we have described, but two of these batteries have been removed to the St. Sever sub-station, to which we shall refer later.

Switch-boards.—The switch-boards are two in number; one (Fig. 5) for the continuous current system, is placed in a long passageway to the right of the entrance to the station; the other is reserved for alternating currents and is located in a large hall in front of the engines. We shall successively give a detailed description of these boards.

The continuous-current board is mounted on a wooden panel 48 feet in length and 11½ feet in height. It is divided into three well-defined parts—for the terminals of the different machines, the terminals of the accumulator circuits, and for the feeder connections.

The terminals of the machines comprise the circuits of the Brown and Thury machines and the continuous-current circuit of the Alioth machines. On each of these circuits is found the apparatus necessary for their handling. For the circuits of the Brown machines we find successively, as may be seen in Fig. 8, extending from above downward, a main cut-out, an ammeter, a voltmeter, a magnetic cut-out and a commutating switch. The magnetic cut-out is provided with windings traversed by the main current, and breaks at the same time the main circuit and the field circuit. In the secondary coils the current may be cut off at will by a switch placed at the side. The commutating switch permits the sending of the current directly into the outer circuits or into the storage batteries.

The circuits of each Thury dynamo have

3. The group of Willans engines and Alioth dynamos is composed of four engines, *F, G, H, I* (Fig. 5). Every one of the dynamos is run by a triple-expansion Willans engine of 200 HP at 170 pounds pressure per square inch, and 460 revolutions per minute. As is well known these simple engines can be run either condensing or non-condensing.

Each Willans steam engine is direct-connected by means of a flexible Raffard coupling to an Alioth dynamo, which can furnish a continuous or an alternating current, or both at the same time. This dynamo has ten field poles projecting radially from an outer spherical frame. At the center is the armature, which has a special Alioth winding. The shaft carries on one side a commutator for continuous currents, and at the rear a collector for alternating currents. When worked by the steam engine this machine furnishes either a continuous low-tension current of 220 to 280 volts, or an ordinary alternating current with a frequency of 38 periods per second, or simultaneously a continuous and alternating current in any proportion.

The steam engine which runs the dynamo can be stopped and the machine run as a motor by a continuous current of about 220 to 260 volts, furnishing in this case an alternating current.

On leaving the Alioth machines the low-tension alternating current is sent into ordinary transformers of 110 KW (*J*, Fig. 5), which raise the tension from 180 volts up to

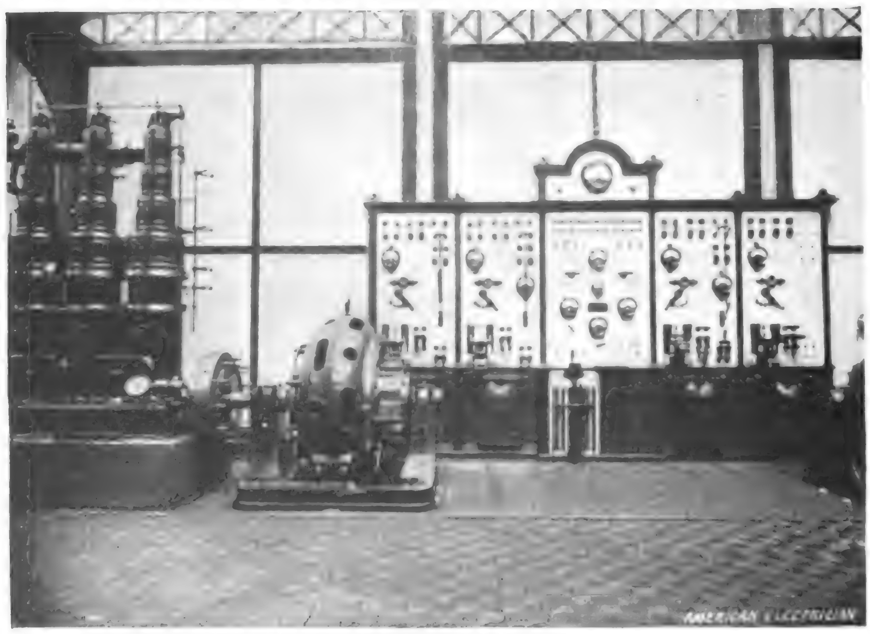


FIG. 7.—ALTERNATING-CURRENT SWITCH-BOARD.

storage batteries and generate alternating currents for distribution at a distance.

The central station now employs two batteries of 70 Tudor storage cells, having a capacity of 1050 ampere-hours. For charging, these batteries require about 150 volts, and about 180 volts at the time of the end of charge. The elements consist of a wooden box lined with lead and enclosing 33 plates, of which 17 are negative and 16

the same apparatus, but there are no commutating switches, since their current is only utilized for lighting. We shall mention particularly, however, the switches of these machines, which have been constructed for 2500 amperes.

As for the Alioth dynamos each continuous-current circuit arriving at the board is provided with an ammeter, which indicates the current furnished by the machine

to the general system or that taken when operating as a motor to produce an alternating current.

As can be seen at the right of Fig. 8, the storage battery circuits comprise an ammeter, which shows the current of charge and discharge, special indicators, and double-contact battery regulators fitted for 600 amperes capacity. These regulators are formed of fifty-one bars, of which twenty-five are dead and arranged between the live bars.

The feeder connections are found at the end of the board. They are on the three-wire system, twelve in number, and lead to the different quarters of the city. Each of them contains two cut-offs, two switches, two ammeters of 400 amperes each, and two rheostats for voltage regulation. The resistances have thirteen sections and permit the absorption of four volts at 400 amperes, four volts at 300 amperes, four volts at 200 amperes and four volts at 100 amperes. Four sections correspond to the first stage, and there are three sections for every one of the other stages.

Between the outgoing circuit of the machines and the feeders there is branched in, a three-wire wattmeter of 8000 amperes, which registers the entire continuous-current energy produced at the station.

The alternating-current board is represented in Fig. 7, where there is also a Willans-Alioth unit. The central portion of the board contains all the apparatus common to four alternators, voltmeters, switches and cut-outs. We also find the apparatus for coupling in parallel, the phase indicator, and at the lower portion a regulator, of which we shall give some of the details. We have seen that at the Alioth dynamos the alternating current has a voltage of 180. It then passes into the transformers (*J*, Fig. 5) of 110 kilowatts, which carry the pressure up to 2000 volts. The regulator mentioned is arranged like a storage-battery regulator and adds or subtracts from the three transformers a certain number of coils in the primary circuits in order to vary the voltage according to need. The voltage of the continuous current may vary, and, consequently, the variations in the voltage of the alternating current may become sensible when the continuous-current motors drive the alternators. The central panel thus reunites all the outgoing circuits from the Alioth dynamo.

Each of the four Alioth dynamos is also connected with a special small switchboard; in Fig. 7 two panels can be made out to the right and two on the left. Each of these small boards may be divided into two parts; to the left is the apparatus for continuous current and to the right for the alternating current. For the continuous current we find successively at the lower portion a field rheostat (common to both circuits), a magnetic cut-out of 600 amperes, a starting rheostat which is used when the dynamo operates as a constant-current motor, an ammeter, a voltmeter and a cut-out. For the alternating current we find first the same field rheostat, a main switch which permits the opening or closing of the circuit, a switch for the purpose of putting into service the corresponding transformer, an ammeter, a cut-out on the primary circuit, and finally a switch and a cut-out on the high-tension secondary circuit. One can understand that with these various apparatus and switchboards it is easy to carry out the different operations we have indicated for the working of the continuous and alternating currents.

We may add that the switchboards are excellently arranged and with the greatest attention to system. These qualities were indispensable in the present instance on account of the complicated system of distribution. As may be seen in the different illustrations, there are in the station two traveling cranes, one of a carrying capacity of 11 tons and the other of 16 tons.

FIG. 8 —CONTINUOUS-CURRENT SWITCHBOARD.

Distribution.—The lines for the three-wire continuous-current system are above-ground. The initial cut shows the wires as they issue from the station to supply the central portion of the city.

The conductors which connect the central station with the sub-stations, which we shall describe later, are underground and arranged in concentric cables made by the Société Cail of Paris. We have seen that the current thus transmitted is an alternating current of 2000 volts.

The Sub-stations.—The three-wire system of distribution serves only to supply the central quarter of Rouen. For supplying the outlying quarters the company employs the alternating current. The first sub-station has been installed in the Saint-Sever quarter. A series of other similar sub-stations are to be established in the future in different other quarters. The Saint-Sever sub-station contains an Alioth dynamo similar to those at the central station and two batteries of seventy accumulators each, also similar to the batteries of the central station. The Alioth dynamo receives the alternating current transformed at low tension at its arrival, and furnishes the continuous current which supplies subscribers directly and charges the accumulator batteries. Work is being carried on at present at the installation of several sub-stations.

Financial Results.—The electrical central station of Rouen is one of the central stations in France which have so far given the happiest results. The company which carries it on was founded with a capital of $200,000, and, as we have said, it has just obtained a new concession for fifty years.

At the end of 1896 the total number of lamps connected with the system was 35,000. The selling price of the KW-hour was about 12 cents in 1896. The total receipts during this year were about $130,000. If we consider that the city has a population of 110,000 inhabitants, it will be seen that the Société Normande d'Électricité may yet hope for a considerable increase of business.

SINGLE-PHASE MOTORS.

BY ERNST J. BERG.

Although single-phase motors have been built for several years, almost every month some inventor brings out a "novel and perfect" motor. Yet we see very little if anything of them in commercial operation; in fact, I believe that many consider the single-phase motor problem still far from solved. A number of types have indeed been built, but few have left the experimental departments.

Single-phase synchronous motors have been in commercial operation for years, and are, of course, well known in the art. We all know that they operate perfectly satisfactorily when brought in synchronism with the generator, but they must be brought in synchronism with the generator before they can be used as motors; that is, it is always necessary to have a smaller motor or other motive power in connection with such single-phase synchronous motors.

The characteristic features of a single-phase synchronous motor are that, like the multiphase synchronous motor, it can be used as motor only, or partly as motor and partly as compensator for idle currents in the system, or wholly as compensator.

Its maximum input when used as motor is the same as that as a generator with the same excitation; the maximum output is thus a little smaller, assuming the generator and motor capacity limited by heating. In order to run non-inductively its field excitation should be varied with the load.

If the excitation is constant and so adjusted that the motor runs non-inductively at full load, the current will be leading at light loads and lagging at overloads.

Thus at light loads it will compensate more or less completely for lagging currents in the system and at overloads will add lagging currents, thus lowering the power factor of the system.

However, in a well-designed synchronous motor the regulation is made so that although the field excitation is left constant

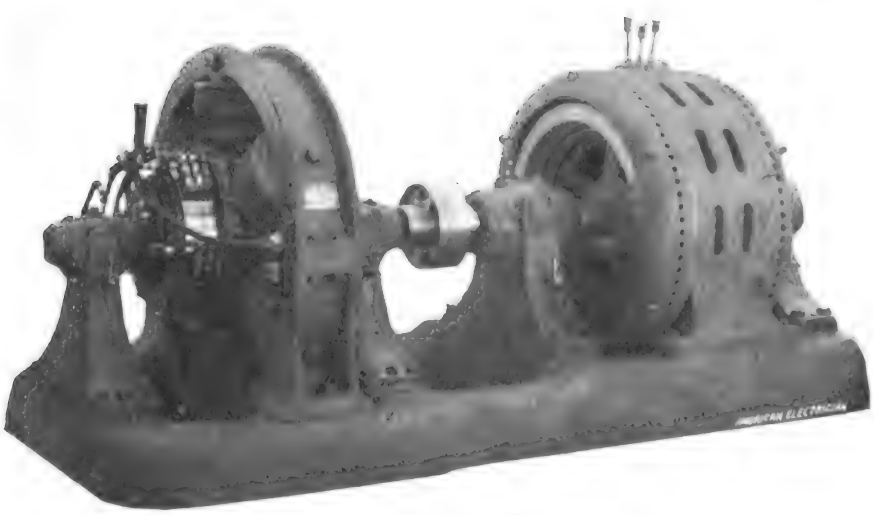


FIG. I.—100-HP SINGLE-PHASE INDUCTION MOTOR.

at all loads no appreciable idle current will flow in the system; consequently the only drawback with this type is that it is not self-starting.

The aim of inventors during the last years has, therefore, been to devise a single-phase alternating motor which will start of itself, and in starting and running have the advantages of a direct-current motor.

Naturally the first suggestion was to use a common direct-current shunt or series motor on an alternating circuit. Even without any theoretical reasoning we can see that this has not proved a success, since few, if any, such motors have been in commercial operation during these years, excluding perhaps a number of small motors,

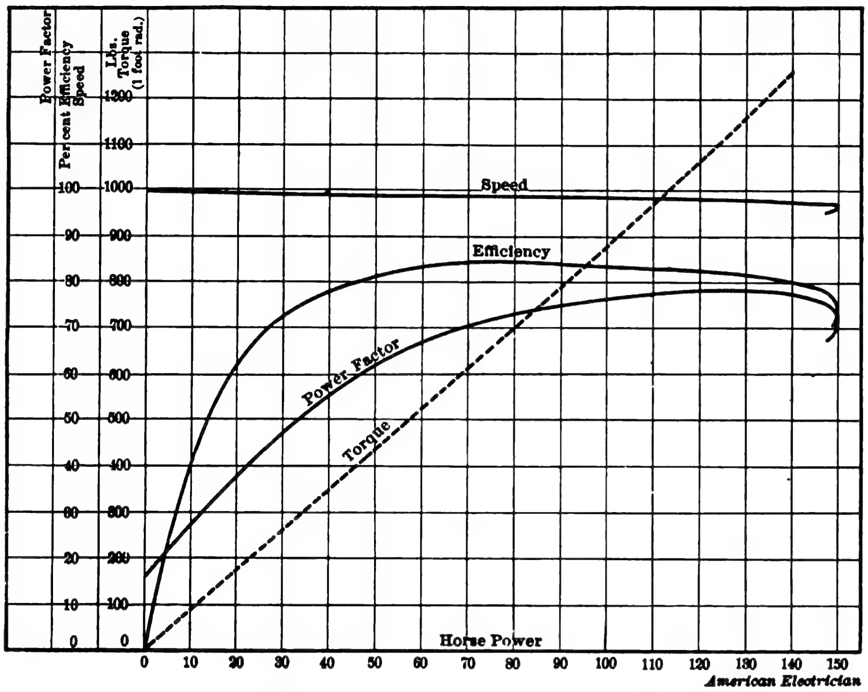


FIG. 2.—LOAD CURVES OF SINGLE-PHASE INDUCTION MOTOR.

most of which can be classed as merely toys.

Commutator motors have been built of essentially three different types, the alternating-repulsion motor, the alternating-shunt motor and the reaction motor.

In the two first mentioned types the chief objection, and indeed the absolute prohibitive feature, is the necessarily deteriorating sparking at the commutator. This sparking cannot be overcome, since at any position of the armature coil an E. M. F. is induced therein, especially so in the position where the coil is short-circuited by the brush; this coil acts as a short-circuited secondary in a transformer with the total field as primary, thus taking a very large current, which endangers the coil by overheating, and causes destructive sparking.

The alternating series motor has furthermore the great disadvantage of not having a definite speed. This is much more marked in these motors than in direct-current series motors, since in the latter the torque rapidly decreases with the speed, and thus the motor lacks power to reach too high speeds. In alternating series motors, however, the torque decreases very little with the speed, so that there is always a danger of their racing until they fly in pieces.

In this respect an alternating-current motor behaves very much the same way as a continuous-current motor operating on a constant-current circuit. It can, however, be made to start with considerable torque, and when properly adjusted will give considerable output, but is always running at a very low power factor, and consequently with large currents corresponding to all outputs and low efficiency.

An alternating-current shunt motor has similar disadvantages. It can start with considerable torque, since, in starting, the current in the armature and that in field are almost in phase, both being 90° behind the impressed E. M. F.; but as the armature revolves the induced E. M. F. is in phase with the field magnetism and the current would be 90° behind the current in the field; thus wattless. Since, however, the field circuit contains some resistance and hysteresis, the current lags always less than 90°; thus the motor has some power.

The repulsion motor is by far the best of alternating motors with commutator. The objectionable part, the commutator, is only used in starting, and is short-circuited when the motor is in synchronism and when it behaves as, or rather is, a straight induction motor. The sparking at the commutator on such motor is decidedly less than in the series or shunt motor. The

torque efficiency in starting is higher than any other single-phase starting device, and this method of starting single-phase motors would therefore be the best, provided that the commutator could be made cheaper and constructed with a sufficiently low voltage per bar, which is practically impossible.

Finally, single-phase, alternating-current, synchronous motors have been supplied with a commutator which has been used in starting and short-circuited when the motor has reached speed. This method is used to some extent, but has not been of much commercial value, since in this type the volts per commutator bar are necessarily very much higher than in any other of those mentioned above, and the sparking is more fierce. Motors of this type may be built for small units, but are certainly impracticable for larger sizes; especially when starting torque is required.

With the introduction of multiphase induction motors without moving wires, commutators and brushes, the earnest desire of all inventors has been to reproduce this type for single-phase circuits, and indeed the question seems to be solved, since a number of single-phase induction motors have been in commercial operation for some time.

The induction motors are built on the same line as, and in fact are identical with, the multiphase motors in almost all respects. With the starting device they start with any desired torque, and consume in starting only 30 or 50 per cent. more current per pound of torque than when running; their efficiency, although necessarily somewhat lower than that of multiphase motors, almost reaches the values of continuous-current motors. Their power factor is comparably high, much higher than it is possible to attain with commutator motors.

Figure 1 shows a 100-HP single-phase induction motor built by the General Electric Company, and now in commercial operation in the Narragansett Electric Lighting Company's power station in Providence, R. I. This motor is direct-connected to a continuous-current generator. It has twelve poles and runs at 600 revolutions and is wound for 2000 volts, being supplied directly from the mains.

In Fig. 2 are given the more interesting data on the behavior of this motor. As seen, the efficiency, power factor, torque and speed are plotted at all outputs.

Of particular interest is the small drop shown in speed. At full load the drop amounts only to 1.5 per cent. The efficiency is above 80 per cent. over a considerable range of loads, as will be seen from the accompanying table, giving data from one-quarter load to overload:

Load.	Efficiency.	Power Factor.
At ¼..........	68 per cent.	48 per cent.
At ½..........	81 per cent.	64 per cent.
At ¾..........	84.5 per cent.	72 per cent.
At full........	82 per cent.	76 per cent.
At 25 per cent. overload.	82 per cent.	78 per cent.

The maximum output is 50 per cent. in excess of the full-load output.

The starting device used with these motors consists of a reactive coil in series with a non-inductive resistance connected across the mains. A wire taken from the junction between the resistance and the reactance is carried to one terminal of the induction motor, the other two terminals of the motor being connected directly to the mains. The action of the starting device is briefly as follows:

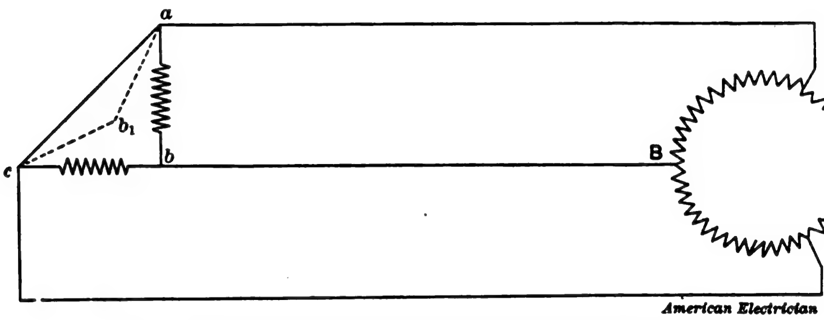


FIG. 3.—DIAGRAM OF E. M. F. OF SINGLE-PHASE INDUCTION MOTOR.

At open circuit the current at the motor terminals and across the reactance and resistance consumes an E. M. F. in phase with the current in the resistance part and an E. M. F. in quadrature thereto in the reactance part; thus, the E. M. F. between the junction and any of the mains is out of phase with the main E. M. F., and we have by this arrangement established an out-of-phase E. M. F. similar to that of the monocyclic system.

This is illustrated in Fig. 3, where $a\ b$ represents the E. M. F. across the resistance, $b\ c$ the E. M. F. across the reactance and $a\ c$ the impressed E. M. F. It is evident that when energy current is taken from line $b\ B$ the triangle droops down and may be reduced to triangle $a\ b_1\ c$. In starting current is supplied from b to the induction motor. As the motor speeds up this current decreases, becomes zero when the counter E. M. F. of the motor is equal to the impressed E. M. F. at b_1, and finally, when the motor approaches synchronism, current is supplied from the motor back to b_1. Thus, in starting, this device gives essentially the same results as the quarter-phase system, but in running, even if b is connected to the motor, the motor works as a single-phase motor.

Since there is some wasting of power across the resistance part of the starting device, it is not economical to leave the device in when the motor has reached speed, the practice being, after speed is up, to cut out the starting device and run on the two mains alone.

THE ECONOMICS OF POWER TRANSMISSION.

BY DR. LOUIS BELL.

In the last resort all the problems of power transmission are adjudicated before the court of dollars and cents. If a given project does not seem likely to pay, it is promptly turned down. It is therefore of the greatest importance to understand what items of cost go to make up the total bill which must be met, and also, since one must draw up a sort of trial balance, to determine what are the probable sources of revenue.

There are plenty of chances for mistake in making the entries on either side of the account, but at the present time enough experience has been accumulated to make one who has profited by it to at least avoid gross errors.

Strange to say, the most egregious blunders have often been made in estimating the receipts which may reasonably be expected. In order to make power transmission pay there must be a certain sale for the power at a fair price. Right here is where the majority of transmission projects are weak. There is no use, generally, in delivering power to the village of Wayback, Lost County, in the hope that a second Chicago will grow up about your plant, for you will have no such luck. If a working majority of the existing population is made up of catfish and ground-hogs, just stop and think how much electric power catfish and ground-hogs need, and what they are likely to pay for it. It will not pay to await the work of evolution.

This warning may sound very needless, but the writer has seen more transmission schemes foreordained to fail from lack of market than from any other one cause. Unless a place has commanding advantages of a very unusual character, it is not safe to count upon a market greatly exceeding the present one. In this connection it is well to remember that there is no more cheerless financial limbo than a town which lies flattened under a collapsed boom.

In taking up, then, a power-transmission project almost the first thing to be done is to examine very thoroughly the possibilities of the proposed market. To this end a sort of unofficial census of lights and power used should be taken—the more complete the better. It is generally not difficult to find out quite closely how many and what sized engines are being used in town. Not so easy, but still a practicable task it is to find out roughly how heavily loaded they generally are. With a list of the engines in use and their approximate power, one can get a pretty clear idea of the prospects for selling power. It is very seldom that one can make a clean sweep of the engines in use—there are always some who will hang back long after their neighbors have proved conclusively that electric power pays. Just what proportion of the total can be converted it is often very difficult to predict. In fairly prosperous times one should be able to get a grip on perhaps three-quarters of the plants under

50 HP, and half the plants over that size, within a reasonable time.

Anything more than this would be unusual good fortune unless in a very small and enthusiastic town, in which even the total power is not large. Under ordinary circumstances a power plant that secures, within a year or two, half the aggregate power used in town is doing quite as well as the promoters have any right to expect. After the project is really under way, a more accurate canvass should be made.

A similar preliminary investigation should be conducted regarding the prospects for electric lights. If there is no gas plant or other electric plant as a competitor one would naturally expect a fine business; but in places so small as to be free from this competition it is rare to find first-class prospects. It is somewhat difficult to estimate lighting possibilities accurately, but experience indicates that in places where the only competitor is gas, one may reasonably expect to install one incandescent lamp for, say, every five inhabitants. In some cases, where gas has been costly, one can do better than this, perhaps connecting one lamp for every three or four inhabitants, while if conditions are adverse, one lamp for six or seven people is the best that can be done.

In these days incandescent lamps are nearly always furnished by meter, so that it is important to form some definite idea of how much the lamps installed will be used. Here, again, conditions vary widely. Commercial lamps may be in use an hour and a half or two hours a day. Residence lighting gives much less return—often not not more than half an hour per day; churches, halls and theatres are little better, and the few all-night lamps are welcome to swell the total. An average of an hour per day is doing very well, unless one is lucky enough to have a large proportion of commercial lighting. For arc lamps no good rule can be given, but, for a rough guess, if the street lighting can be obtained it ought to amount to, say, one arc for every 200 or 250 inhabitants.

With these approximate data one can form a tolerable idea of the chance for business. Perhaps the best way of grasping the situation is to take an imaginary concrete case and see what the commercial situation is likely to be.

Suppose you are contemplating a power plant to supply the needs of a thriving city of, say, 25,000 inhabitants, and the source of power is to be a water privilege 15 miles distant.

Your preliminary figuring shows the use of about 2,000 HP, nearly half of it in units under 50 HP. Coal being rather high, say, $4 to $5 per ton, there seems to be a good chance for electricity. With good fortune you may pick up in the course of a year or two 1,000 HP in motors, big and little. To do this you are likely to have to make considerable concessions to big consumers in one way or another. The gross receipts from this business depend, of course, on what you are able to get for power. With coal at the price mentioned, the power ought to yield certainly $50 per HP per year. This would be $50,000 per year nominally, but even if you have taken the 2,000 HP as representing power actually used, not merely engine ratings, you are still likely to find receipts cut down by intermittent use uncompensated by your increased rates to, say, three-quarters of the above—$37,500.

Then as to incandescent lamps, you will probably install 5,000. If you have good luck in getting commercial lights, you may get an hour's burning per day on the average. At the price ordinarily charged—1 cent per lamp per hour by meter—this would amount to $18,250 per year, which is likely to be reduced by discounts of various sorts to, say, $16,000.

Then for the arc lights. If you stand in with the powers that be you should be able to accumulate perhaps 125 street lamps, and you should get about $80 per year for them, although you would not probably look askance at $75, particularly if some of the aldermen have the municipal plant bee in their bonnets. The latter figure would give an income of $9,375. Adding these various items you have a probable gross income of $63,875, say $65,000 in round numbers, allowing some increase for commercial arcs and various odds and ends of special business.

Now, is this business sufficient to justify you in going ahead with your plant? To answer this question you will have to make a preliminary estimate of the cost of the plant and the operating expenses. Your first task is to estimate the capacity of plant required. The nominal 1,000 HP output of the motors does not mean that 1,000 HP must be continuously supplied. On the contrary, it is more than probable that even the maximum motor load will not reach this figure and will scarcely ever exceed 700 to 800 HP. Of the 5,000 incandescents connected, you may be quite certain that not more than 2,500 will be burning simultaneously, unless on the evening of some public illumination. The arc lamps furnish a steadier load, and you may perhaps have 150 or so on at once, for which you may roughly allow a HP apiece, while the incandescents may run 10 to the HP. In all the maximum load will probably be between 1,000 and 1,200 HP.

In transmission work due allowance must, of course, be made for losses in machines, lines and transformation, and in rough approximations it is common to estimate one KW in the plant for each HP delivered. Your plant in this case should aggregate nearly 1,500 KW in, say, three 500-KW units. Of these one will practically constitute a reserve, since during most of the year two generators will easily carry the load. The third machine may occasionally be in use for brief periods, but is mainly a relay in case of need. To drive these machines a little over 2,000 HP must be delivered by the wheels at maximum load, which means that their aggregate rating should be about 2,000 HP, to supply which there should be ample capacity in the water supply.

In erecting the plant by far the largest single item will be the hydraulic development and rights. The cost of water power is very various, according to conditions. Sometimes it can be obtained at a nominal cost on Government or State lands, while more often it is held at a stiff valuation. Then the cost of development may be almost anything, according to the topographical conditions. Under ordinary circumstances $75 per effective HP should easily cover total cost up to the wheels. At this rate your water power for the proposed plant would cost $150,000.

Next in order comes the wheel plant. The price of this varies considerably with the head in use. Under fairly favorable conditions $25,000 should put the wheels in place ready to run, with all their accessories. As to the station, $7,500 should erect it, exclusive of the electrical equipment, and $2,500 more should furnish a comfortable dwelling for the station men and extra storage room in the shape of a small barn. The generators, station equipment complete and the bank of raising transformers and its accessories should be put in ready to run for $50,000.

Then comes the transmission line, which is often looked upon as a very formidable part of the investment. In point of fact, it is usually a rather small item, often not more than 10 per cent. of the total cost of the plant and rarely over 25. In a case like this the three-ph se system would almost certainly be used for the transmission, and working voltage, unless climatic conditions were unusually severe, could be made, say, 10,000 volts at the receiving end, allowing 1,000 volts drop at the full load of 1,500 KW. Aside from the transformers, the cost of the line is really a comparatively small item. For computing the cost of such a line a wonderfully simple formula suffices:

$$P = \frac{p\, D^2_m \frac{W}{V}}{V_1}$$

Here P is the total cost of the bare line copper in dollars; p the price of bare copper per pound in *cents;* D^2_m the square of the distance of transmission in thousands of feet; W the total *watts* delivered; V the voltage at the receiving end, and V_1 the volts lost in the line. Inductance is not here taken into account, being regarded as compensated by a suitable increase of initial voltage or annulled by an over-excited synchronous motor, as can frequently be done in a mixed plant, such as we are considering. The formula is accurate to within a small fraction of 1 per cent.

Computing thus the cost of the copper, and counting in a suitable sum for stringing it, we find the cost to be about $15,000, exclusive of the pole line and insulators. Ten thousand dollars would be a liberal estimate for the 750 poles required, with cross arms, insulators and telephone circuit all in place; $25,000 for the line complete.

We have now reached the sub-station and the distributing circuits. In the sub-station are the office and storeroom of the company, the bank of reducing transformers, the regulating apparatus for the secondary circuits, and other accessories. The treatment of the arc lighting in a transmission of this kind is always rather a puzzle. Save for a few alternating arc lamps used where convenience indicates, the work will usually be done by continuous currents,

derived from special arc generators at the power station, from motor generators at the sub-station, or perhaps from synchronous rectifiers. At the distance in question, it is quite probable that the cheapest plan would be to work the arc circuits direct from the power station, unless the circuits at the distributing end would have to be unusually long. The more general case would involve motor generators, which we will here suppose to be used. The apparatus for the sub-station would then include the step-down bank of big transformers, arc motor generators for 150 lights, arc and alternating, switchboards and regulating apparatus. These, with a suitable building to serve the purposes of a sub-station, would amount, say, to $30,000. Then come the distribution circuits, with such arc lamps and transformers as are necessary. If one has fairly good luck, $40,000 should cover these items. We may now sum up the items of cost as follows:

Water power, 2,000 HP developed...........	$150,000
Wheel plant, set..............................	25,000
Power station buildings.....................	10,000
Electrical equipment of power station.....	50,000
Transmission line complete................	25,000
Sub-station and equipment................	30,000
Distribution circuits........................	40,000
Total...................................	$330,000

Now allowing 6 per cent. interest on this investment and setting aside 4 per cent. additional for sinking fund, the annual fixed charge becomes $33,000, leaving $32,000 for expenses and additional profit.

Next, the general operating expenses must be estimated. For continuous operation four good men will be required at the power station. At the sub-station there will be needed, all told, six men, besides the superintendent, bookkeeper, etc. A team should also be kept. Of these men the superintendent should be a first-class electrician and should have two good assistants, one at the power station and one at the sub-station. Two others of the force should be picked men, one as assistant at the power station, the other at the sub-station. The others would be trimmers, linemen and helpers. In addition, we must make allowance for insurance and taxes, general supplies, current repairs and office expenses, and the like. These will foot up to a very considerable sum. The various miscellaneous expenses run up with surprising rapidity in an enterprise of this kind. We may tabulate these various items of operating expense about as follows:

POWER STATION.		
One man at............................	$1,200	
One man at............................	960	
Two men at $720........................	1,440	
		$3,600
SUB-STATION.		
Team..................................	$600	
One man at............................	1,200	
One man at............................	960	
Four men at $720.......................	2,880	
		5,640
GENERAL.		
Superintendent........................	$3,600	
Bookkeeper............................	960	
Clerk.................................	720	
Insurance and taxes...................	1,500	
Repairs—Miscellaneous.................	2,500	
Supplies..............................	1,500	
		$10,780
Total.................................		$20,020

The total normal operating expense is thus very nearly $20,000 for the plant and the total expense becomes about $53,000, leaving $12,000 for surplus or dividends.

Now, if the plant in question is built for cash as a *bona-fide* investment, it is evident from these figures that it would net about 8 per cent., with, as business increased, a probability of clearing 10 per cent. or more. If built entirely on borrowed capital it would pay all charges and net about $12,000 per year, for a 4 per cent. sinking fund is competent to allow for all depreciation and to clear off the bonds in, say, thirty years. On the other hand, this plant, if promoted on the plans common five or six years ago, would now be in the hands of a receiver. It would have been bonded for, say, $600,000, with stock for an equal amount, and the bonds would have been placed with friends of the directors at about 80. Then the promoters would have received all the bonds and stock left by the deal for various rights and franchises, and a president would be deputed at about $5,000 per year to jolly possible stockholders. The income would thus be eaten up by fixed charges, and at the first call for considerable repairs or dullness of business there would be a nice deficit. Conducted on an honest, conservative basis, power transmission will nearly always pay, frequently very handsomely.

To analyze our estimates a little, water power is the largest and most uncertain item of cost. It may range from $50 to $100 per effective HP at the wheels, and sometimes outside even these wide limits. The wheel plant will generally cost complete $10 to $15 per HP. The dynamos with their equipment will usually cost, say, $25 per KW, the large transformers and their equipment $8 to $12 per KW, and the transmission line at distances of 10–20 miles $15 to $30 per KW. The building, distributing circuits and such like items may cost a very various amount, say, from $15 to $35 per KW.

The transmission line itself is obviously not a large item in the cost of the complete plant. On the other hand, it is a very important factor in the successful operation of the system. On its continuity depends the commercial value of the installation, for no man wants to buy power which may or may not be delivered when he needs it.

The line therefore must be very thoroughly insulated and constructed, and must be carefully looked after. The circuits should be in duplicate and so located that repairs can be made in one while the other is in use. A road should run close to the line so that it can be inspected easily and reached by a repair wagon on very short notice. Only the best material should be used. The insulators, in particular, must be of the best quality and rigorously tested. The best porcelain should be non-hygroscopic and vitrified clear through, showing a brilliant, almost glassy fracture, under the surface of which the ink from a well-filled pen will not penetrate at all. Thickness is not at all essential, save as it may be needed for strength; a cheap porcelain coffee cup will withstand far higher voltages than have yet been commercially ventured. Care pays everywhere in a power-transmission system, but nowhere better than in the line.

MULTIPLE-EXPANSION ENGINES AND THE COST ACCOUNT.

BY PROF. R. H. THURSTON.

Every problem of the designing and constructing engineer, as of every manager of works of whatever kind, resolves itself ultimately into this:

Required, the provision of a certain amount of power, constant or variable, or more generally stated, the accomplishment of a specified task in engineering, at the least *total* cost, including the original outlay and the capitalized cost of operation continuously, and with maintenance and ultimate replacement.

In the determination of the best system of provision of steam power for a light or power station, this problem often takes a form demanding answers to the questions: What kind of engine shall be adopted? Shall it be a simple, a compound or a triple expansion? Shall it involve the use of low, of medium, or of high steam pressure? What proportions of engine and boiler shall be adopted in either case?

The study of these questions compels the consideration of certain fundamental principles, and of several well-ascertained facts, which, while not at all novel to experienced designers and business men, are, nevertheless, not as familiar to the average practitioner as he would himself desire. The purpose of this article is to state briefly the facts and principles mainly influential in determining the solution of such problems.*

It was shown by experiment, a generation ago, by D. K. Clark, by G. A. Hirn, in England and in France respectively, and by Engineer-in-Chief Isherwood, in the United States—mainly, perhaps, by the latter—that, with the old-fashioned simple, low-pressure condensing engine, even of large size, it is impracticable to adopt economically a higher ratio of expansion when carrying 25 to 40 pounds pressure, by gauge, than about 2.5. It was proved that with greater expansion the internal wastes of the engine, beyond this point, increase more rapidly than do the gains by increasing expansion of the steam in the cylinder. The fact is that, with this class of engines, the steam pressures varying, the expansion adopted should be such, as a maximum, that the terminal pressure, on the expansion line of the indicator diagram, should be not far from 15 pounds per square inch above the zero line, that of perfect vacuum. With the non-condensing engine, the early experience of Sickels, of Corliss and of Greene similarly indicated a limit for the terminal pressure of not far from 20 pounds above vacuum, or 5 pounds above the atmosphere into which the steam is discharged. Thus it became customary to adjust the valve-motion, and to adopt sizes of engine, in such manner as to provide the required power at points of cut-off ranging from 2 to 3 and to 4, in the case of the former, as pressures rose from 25 to 30, and to 50 and 60 pounds, by gauge, at the engine, and from 3 to 4, and to 5, as, in the latter, the rise occurred from 60 to 80 and to 100 pounds.

*See also articles in this journal February, June, 189·, and February, 1897, on this general subject.

It was also observed by the most acute of these early builders, and by their ablest customers among men of business, that with cheap fuel it was not economical to adopt even the sizes of engine thus prescribed, as the gain by saving of fuel was not commensurate with the increased costs of the larger and expensive types of engine best suited to give a good steam distribution with such expansion. Hence, in the neighborhood of coal deposits still lower ratios of expansion and cheaper types of engine held their place against the newer machines, except where the choice was dictated by the requirement of close regulation. Thus the old link-motion and small engines with high mean pressures in the cylinders, the ratios of expansion restricted to below 2, with even quite high pressures, here retained their place. The account of total expense of power, as shown on all accounts on the books of the treasurer, was thus made a minimum by the adoption of sizes and styles of engine which were not regarded as economical in the sense of providing the required power at least cost on the fuel and steam account simply.

From about 1854 it gradually came to be recognized among designers and users of steam machinery that the double-cylinder or so-called compound engine invented, as claimed, by Watt, and actually introduced by Hornblower a hundred years ago, was capable of reducing the expenditure of fuel and of steam in a paying degree when sufficiently high pressures were employed. Hornblower failed when using steam at a few pounds pressure; Randolph and Elder succeeded when employing what was in their time thought high steam pressure.

The reason of this superiority of the compound over the simple engine at high pressure was after a long time shown to be due to the fact that with similar expansion, at ideally economical ratios of corresponding magnitude, the new type was less subject than the old to internal wastes, and that therefore the limit to economical expansion was dropped to somewhere about 10 pounds terminal pressure instead of 15, and in some cases still further. The economical ratios of expansion thus rose 50 to 100 per cent., with the introduction of the better class of compounds, with condensation, and less, though often in nearly equal proportion, with high-pressure non-condensing machines.

The same qualification, however, was noted as in the preceding case, and cost of power on all accounts was made a minimum by restricting the ratio of expansion and the sizes of engines somewhat; accordingly as fuel and machinery varied in cost in differing ratios, the one to the other. Expensive fuel and cheap construction dictated comparatively high ratios of expansion with large engines and small boilers, while the reverse was found best with cheap fuel and expensive constructions of engine. The general fact also appeared that the simple engine was, on the whole, best at low pressures, and the compound at high pressures, and that increased complication and cost were only justified by ability to adopt high pressures and by the necessity of paying high prices for fuel.

In the year 1874 the introduction of the triple-expansion engine at sea by Dr. Kirk, on the steamship "Propontis," proving successful, that type of engine came rapidly into use, and it is now superseding in many cases the compound, precisely as the latter earlier superseded the simple engine. It was found by cautious and successful experience, and gradual progress in the elevation of steam pressures and in the increase of the ratio of expansion in somewhat similar proportion, that precisely as the rise in pressure from the time of Watt to the middle of the century gave opportunity for the economical employment of the compound engine, so the rise from the 75 or 100 pounds, usual in the operation of the compound engine, to the higher figures of the present day, permitted the displacement of that engine by the newer type. To-day, with pressures approximating 200 pounds at the boiler, the triple-expansion engine is, in turn, yielding on the records for economical use of steam and heat and fuel to the quadruple-expansion engine. General experience is now sufficient to justify the deduction that each of these types of engine is best for a certain range of pressures and under certain now well-understood conditions. It is now known, both through these experiences of the century and through a knowledge of the true theory of the multiple-cylinder engine, that its superior economy is derived simply by its reduction of the internal wastes of the engine. Isherwood's deduction that the single cylinder cannot, if unjacketed, profitably utilize the work of expansion beyond a ratio of between two and three is the fundamental fact of this case. It is only by placing cylinders in series, each with a low expansion ratio, that the thermo-dynamic advantages of very high-pressure steam can be realized. The available pressures and expansion ratios increase rapidly with the number of cylinders in series, as thus: *

MULTIPLE - CYLINDER ENGINES. (CONDENSING.)

No. cyls.	1	2	3	4
Ratio	2.5 to 3	6.3 to 9	16 to 27	40 to 81
p_1 (abs.)	25 to 30 lbs.	60 to 100	120 to 300	350 to 800

In such a series each cylinder is working steam to the best advantage, and in such manner that either increase or decrease of the expansion ratio, to any important extent, would result in loss of economy.

The fact at once becomes notable, on reading these figures, that the range of pressure economically utilizable with the multiple-cylinder engine is very great as we get into the higher order of construction, even with such restricted values of the ratio of expansion. It would seem, in fact, to be doubtful whether we are likely soon to require a quintuple-expansion engine; although the adoption of as low a ratio of expansion as two for each cylinder may give a place for that extent of complication at pressures not yet familiar, or likely to become so at an early date.

* "Manual of the Steam Engine," Vol. 1., p. 597; R. H. Thurston. *Transactions* A. S. M. E., 1889, Vol. X.

The thermo-dynamic efficiency of the steam engine, could all extra-thermo-dynamic wastes be avoided, would increase substantially as the logarithm of the steam pressure, and we should thus anticipate a gain of 50 per cent. in rising from 100 pounds to a 1000; but it is only by keeping down those wastes that we can even roughly approximate the economy thus indicated by science as the limit of possibility. The reason of the economy of the multiple-expansion machine is now evident, and the method of attainment of that efficiency is equally obvious. It is seen that each type has its place and its special range of application with increasing steam pressures.

The action of the multiple-cylinder engine in thus reducing the quantity and cost of heat, steam and fuel demanded in supplying the required amount of power is in detail as follows: The steam is received at entrance into the engine into a comparatively small cylinder, of which the proportions are such that the area of interior and comparatively cold metal wall in contact with it is much less than if it were, as in the simple engine, immediately introduced into a large steam cylinder. Further, the ratio of expansion in each cylinder of the series is restricted to that moderate value which is known to involve comparatively slight initial condensation and consequent waste of steam, instead of, as in the simple engine, being the full measure of expansion required to fully utilize the thermo-dynamic potentialities of high-pressure steam; which latter adjustment involves very serious losses in this manner. Still further, the steam rejected at exhaust from the smaller cylinder carries with it all of the fluid initially condensed and once more in the form of completely re-evaporated liquid, less only the amount of that adiabatically condensed—about one per cent. for each unit in the ratio of expansion—and this re-evaporated steam is again, in well-proportioned engines, practically all utilized in supplying the place of the steam initially condensed in the next succeeding cylinder, thus passing from cylinder to cylinder through the series, however large the combination, and thus reducing the total waste by so-called "cylinder condensation" to that fraction which measures the maximum loss in a single unit of the series. This means where the pressure is 100 pounds, for example, and where the compound would expand ten times, a loss with the best engines of perhaps a quarter or one-third of the steam supplied, where in the simple engine it would amount to above a half or perhaps to two-thirds. Similarly the triple-expansion engine should reduce this waste to about one-third that of the simple engine at similar expansions and the quadruple-expansion engine to something like one-fourth.

This not only thus reduces wastes, but effects a still more striking result: The simple engine is found to be subject to increasing proportional wastes of steam as the expansion of the steam is increased, and finally, at a comparatively small value of the ratio, this engine demands more steam per horse-power-hour, with increasing, than with diminishing, ratios of expansion. The sim-

ple engine thus finds an early limit to the profitable utilization of steam by expansion. This limit is evidently removed, in the multiple-cylinder engine, under favorable conditions, something like in proportion to the number of cylinders in series. Thus each type of engine is adapted to a certain range of steam pressure, and can be economically employed only within that range. The compound, for example, if built, as in Hornblower's time, for pressures for which the simple engine was well adapted, would show no great superiority, while its cost would quite preclude its use, in the absence of superior thermo-dynamic value. The triple-expansion engine would not give enough advantage, at the pressures to which the compound specially adapts itself, to compensate its greater cost; while it, in turn, would be displaced by the quadruple machine, were the pressure raised to such a point that the saving effected by the latter would more than compensate the cost of securing that economy.

The question: "*Will it pay to secure the promised saving?*" is, in fact, the fundamental one, and the solution of this problem is the business of the engineer in every professional work. Every such question and every such problem presented to the engineer thus finally resolves itself into the form: "Given a certain amount of power to be supplied, or of production to be effected, or result of whatever specified kind to be accomplished, how can that result be attained at a total, annual, minimum cost, on all accounts chargeable against the work of construction and operation? What is the smallest *capitalized* amount that will provide the machine or the plant and keep it permanently and economically in operation, with, in some cases, a reserve sufficient to either replace it or to replace the capital represented by it?*

This is the real form of the question to be answered when choosing the best form of steam engine for a mill or factory or a power plant. This question requires for its intelligent settlement usually an expert's knowledge of the circumstances and of the limitations, commercial and other, both of the business and of the machinery, and experience in the observation of the performance of the various types of engine available. The expert can usually readily answer the question with at least approximate accuracy from a knowledge of what economy the various classes of machinery have practically exhibited where already in operation. That combination of machinery which, circumstances being similar, has, when gauged by the charges against the whole power system, on the books of the treasurer, shown the lowest continuous costs, for a given power supplied, is the one to choose for the proposed new plant.

Where it is practicable to ascertain with precision the various costs involved and to correctly class them as constant and variable, and to accurately assign each class to its proper place, a beautiful process, original with Professor Rankine nearly a half-century ago, and adapted to our purposes in the light of modern investigation—for, as originally employed by its author, it was of purely scientific interest only, and its results were often absurd as applied to practical work—may be expected to give satisfactory solutions of the class of problems including that now before us.

It is obvious, as stated by Rankine, that, with increasing ratios of expansion, and consequent reduction in the quantity of steam required to perform a given quantity of work, we may adopt steam boilers of decreased dimensions and costs; while, if we reduce the ratio of expansion, under ordinarily satisfactory practical conditions, we must purchase more boiler power while reducing costs of the engine by thus making it of smaller size. Evidently there must be, somewhere, a point at which the oppositely varying costs of engine, and of boiler and fuel, will balance in such manner that variation either way will increase cost on the one side more than it will reduce it on the other, and we may find a certain proportion of engine and boiler which will give us the required amount of steam power at the least possible total costs on all accounts. This proportion will evidently be such as will give us an engine of somewhat less than maximum possible economy in the use of fuel, of less than maximum "*duty*," and a boiler of less than maximum economy in the production of steam, as measured by first cost and costs of operation together, for the design of the boiler involves precisely such a problem of maximum and minimum as does the proportioning of the engine.*

There are many methods of working out the solution of this problem in maxima and minima, the most common one among engineers and builders being that of trial and error; computing the total costs of installation and operation, capitalized for two or more alternative plans, and selecting that which promises minimum total tax upon the dividend-paying capacity of the establishment for the presumed life of the plant. So far as the proportioning of the engines and the boilers the one to the other is concerned, the following simple approximate but probably often sufficient method—borrowed from Rankine, with amendment in the light of modern experience and scientific knowledge—may answer the question: Which of several alternative plans involving choice of simple, compound or triple-expansion engines will be, on the whole, best? This question has for its obvious answer that engine and boiler plant which will, all accounts being studied, show a minimum sum of those costs, varying with the contemplated changing conditions of installation and operation, and of those varying with changing proportions and type of apparatus. It is that design which gives in regular operation under the conditions of everyday work the least total cost of production of the demanded work. To put it in another way, more apposite to our present purpose: that which shows the lowest ratio of cost to quantity of work done—*i. e.*, of total costs on all accounts variable with the conditions prescribed in the problem—to the horse-power developed for the stated time, is financially the best investment, and therefore the best solution of the engineering problem.

Thus, in the figure, let the co-ordinates of points on the several curves measure, respectively, the quantities of work performed and the amounts of steam required to perform that work. If we make the vertical scale one of work or power, taking the unit, for example, as the power developed by a cubic foot of steam, without expansion, and the abscissæ as measuring the fraction of a cubic foot of steam employed to perform the work measured by the corresponding ordinate, we may have a curve, $O\,A\,Y$, which is obviously, as Rankine first showed, what the writer has called the "curve of efficiency" of the *ideal* engine, with its non-conducting cylinder. Its ordinates will be the "adiabatic mean pressures" of an initial unit volume of steam, expanding in a non-conducting cylinder, at ratios of expansion and points of cut-off respectively indicated and measured by the abscissæ of the points identified by these ordinates. For this *ideal* case the ordinates are thus the mean pressures for dry and saturated steam, and for cut-offs represented by the base-line measurements of the diagram.

Suppose it practicable to determine the "curve of efficiency" of the *real* engine, and to lay down a curve, $O\,B$, for example, which shall similarly measure the proportion of the work performed, in the real engine of the desired power and type, operated as proposed. The ordinates of this curve would represent the proportional amounts of work performed by one cubic foot and fractions thereof, as measured on the abscissæ of this new curve. These measures of fractions of the unit quantity of steam, however, would not represent the relative values of the points of cut-off in the *real* engine at which the noted quantities of steam are measured off. These must be determined later.

Let the curve just constructed represent that of the simple engine; assume that we may also lay down the curve, $O\,C$, as that for the compound engine, and $O\,D$ for the triple-expansion; each, as it approaches more and more nearly the ideal condition of operation of steam, by reduction of wastes, thus gives a curve closer and closer to the ideal of Rankine. We may thus, perhaps, secure sufficiently accurate locations and forms of the curves for the types of engines to be practically employed. In fact, it is perfectly possible to secure close approximations to these real curves, if not absolute accuracy, by reference to the data given us by the now numerous reported trials of every type of engine and boiler in general use.

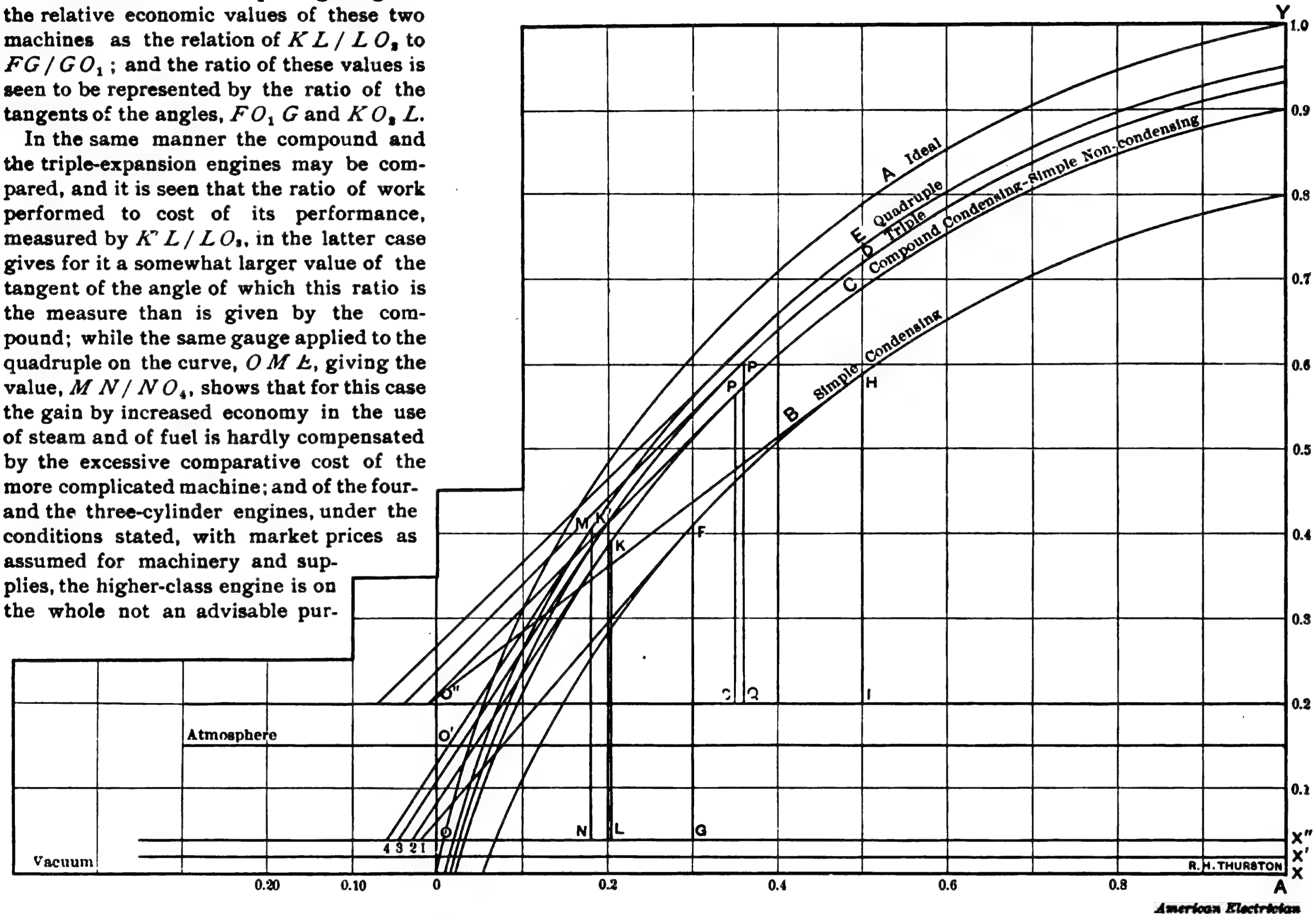
If the abscissa passing through X' measure the back pressure by its distance above the vacuum line, $O\,X$, and if the increased altitude, the intercept, of the abscissa passing through X' gives the added "useless resistances" of the engine—consisting mainly of its friction—the ordinates $F\,G$, etc., intercepted between $X'\,O$ and $F\,H$ will measure the *net* work performed, the power delivered, and the mean effective pressure, as indicated by the brake. The ratio of

*"Manual Steam Engine," Vol. I., Chap. V.; Vol. II., Chap. VIII. (Finance), p. 77.

* "Manual of the Steam Engine," Vol. II., p. 89; also *Trans.* A. S. M. E., 188?; *Journal Franklin Inst.*, 1882.—R. H. T.

FG / OG will be that of power supplied to the cost of that power in steam used, and it is at once seen that, when this is a maximum, the engine will exhibit maximum "duty." Compare for example, the ratio just obtained with that of HI to IO'. It is evident that the former is much the greater, and thus it is obvious that the operation of this engine, non-condensing, will result in considerable reduction of the "duty."* The same method of comparison of the performance of the compound, giving the curve of efficiency, OKC, with that of the simple engine, gives the relative economic values of these two machines as the relation of KL / LO_2 to FG / GO_1; and the ratio of these values is seen to be represented by the ratio of the tangents of the angles, FO_1G and KO_2L.

In the same manner the compound and the triple-expansion engines may be compared, and it is seen that the ratio of work performed to cost of its performance, measured by $K'L / LO_3$, in the latter case gives for it a somewhat larger value of the tangent of the angle of which this ratio is the measure than is given by the compound; while the same gauge applied to the quadruple on the curve, OME, giving the value, MN / NO_4, shows that for this case the gain by increased economy in the use of steam and of fuel is hardly compensated by the excessive comparative cost of the more complicated machine; and of the four- and the three-cylinder engines, under the conditions stated, with market prices as assumed for machinery and supplies, the higher-class engine is on the whole not an advisable purchase. Similarly, also, comparing these several types operated as non-condensing engines on the assumption that water is unobtainable, or even with the modern system of cooling towers, is too expensive for use in condensing,† the ordinates HI, RS, PQ, give the proportion of work done to expenses, measured by the abscissæ of the same points on each curve, and these measures, being accurately established, permit a judgment to be formed of the desirability of one or another of these classes of engine, under financial conditions specified for each case.



FINANCE OF MULTIPLE-EXPANSION ENGINES.

In the case of a light or a power station, supplying electric current, the problem of the designer or user is complicated by the fact that the load is liable to be exceedingly irregular, however exact and careful he may be in dividing it among the units composing his power plant. In this case, the best he can do is to assume the mean load of the period assigned to the engine to be proportioned, as its best load, and design the machine for that or something less, as it is known that the loss by mean loading is commonly less with a properly proportioned engine than that due to overloading; although the consideration of cost as here described gives considerable leeway in the latter direction. Fortunately, in the case in which high efficiency is most important, that with expensive fuel, the most economical types of engine are found to be those having least loss of efficiency with variation from the point of cut-off of maximum duty effect.* A problem which precedes that here discussed, both in order and in importance, is that of ascertaining the actual or probable "load curve," of reducing its eccentricities to a minimum, and of then dividing its period into such parts as will permit the assignment of the best number and sizes of the units of the steam plant.

The method of procedure, *en résumé*, is as follows:

(1) Plan the whole system in such manner as to give the best possible arrangement of the details of distribution, with a view to securing minimum cost, so far as distribution of energy is concerned.

(2) Make the scheme one that, so far as is practicable, will find the steadiest load for the whole period of operation of the plant; as by arranging, where possible, for a day load supplemented by current supply to motors in factories, as by utilizing storage batteries, if finances permit, without too much expense in first cost and maintenance, and by every expedient that will, without more than compensating expense, aid in reducing irregularities of demand, and in making the several unavoidable changes in load as rare and the power demanded in each period as uniform as possible.

(3) Assign periods to the units of steam power in such manner as at once to best serve the customers of the company, and at the same time produce such a power distribution as will give the least total annual costs of operation of the system, all accounts being considered.

(4) Apply this last principle to the selection and the proportioning of an engine for each power unit, in the manner above indicated.

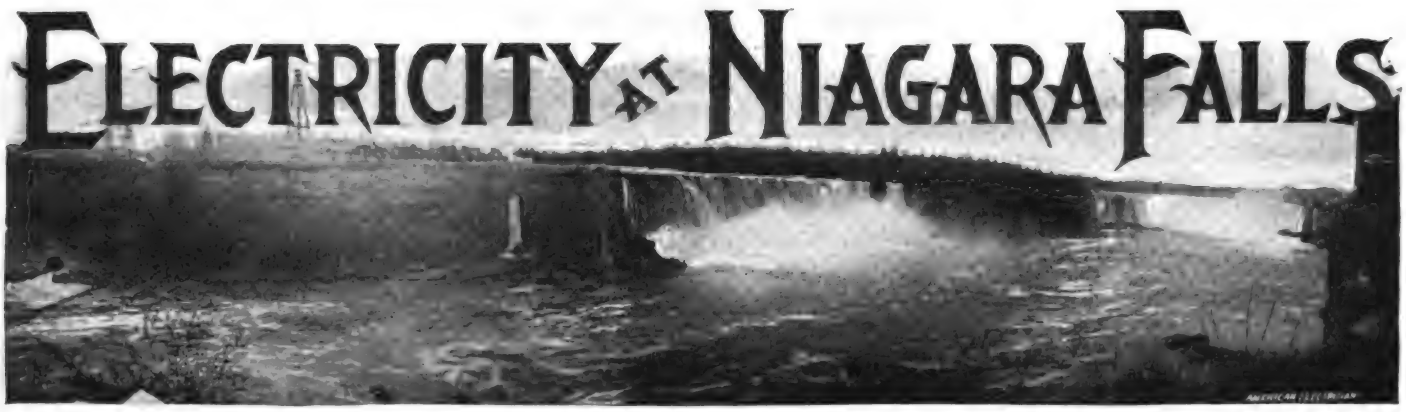
Thus, reducing every cost to a minimum and making each factor of the total efficiency a maximum, the station and its distribution will be certain to prove in maximum degree profitable, if wisely managed.

* It is to be noted, however, that the curve of efficiency of the non-condensing engine will actually be raised above that of the condensing, and thus the difference here noted will be somewhat reduced.

† Costs of water are here to be charged as costs of steam, and added to costs on fuel account.

* See article on this subject, by Professor Durand, in our issue of June, 1896, p. 44.

ELECTRICITY AT NIAGARA FALLS



THE subject of this article is perhaps the most hackneyed in the entire range of periodical electrical literature; indeed, it would be difficult to find a commercial development in any branch of industry which has been more exhaustively described. In what follows, therefore, no attempt will be made to give the usual journalistic descriptions, but instead a brief and concise review will be presented of the present situation at Niagara with respect to electrical development, with particular reference to the newest applications and to details of operation.

Generation.—There are two distinct enterprises of this nature at the Falls. First, that of the Niagara Falls Power Company,

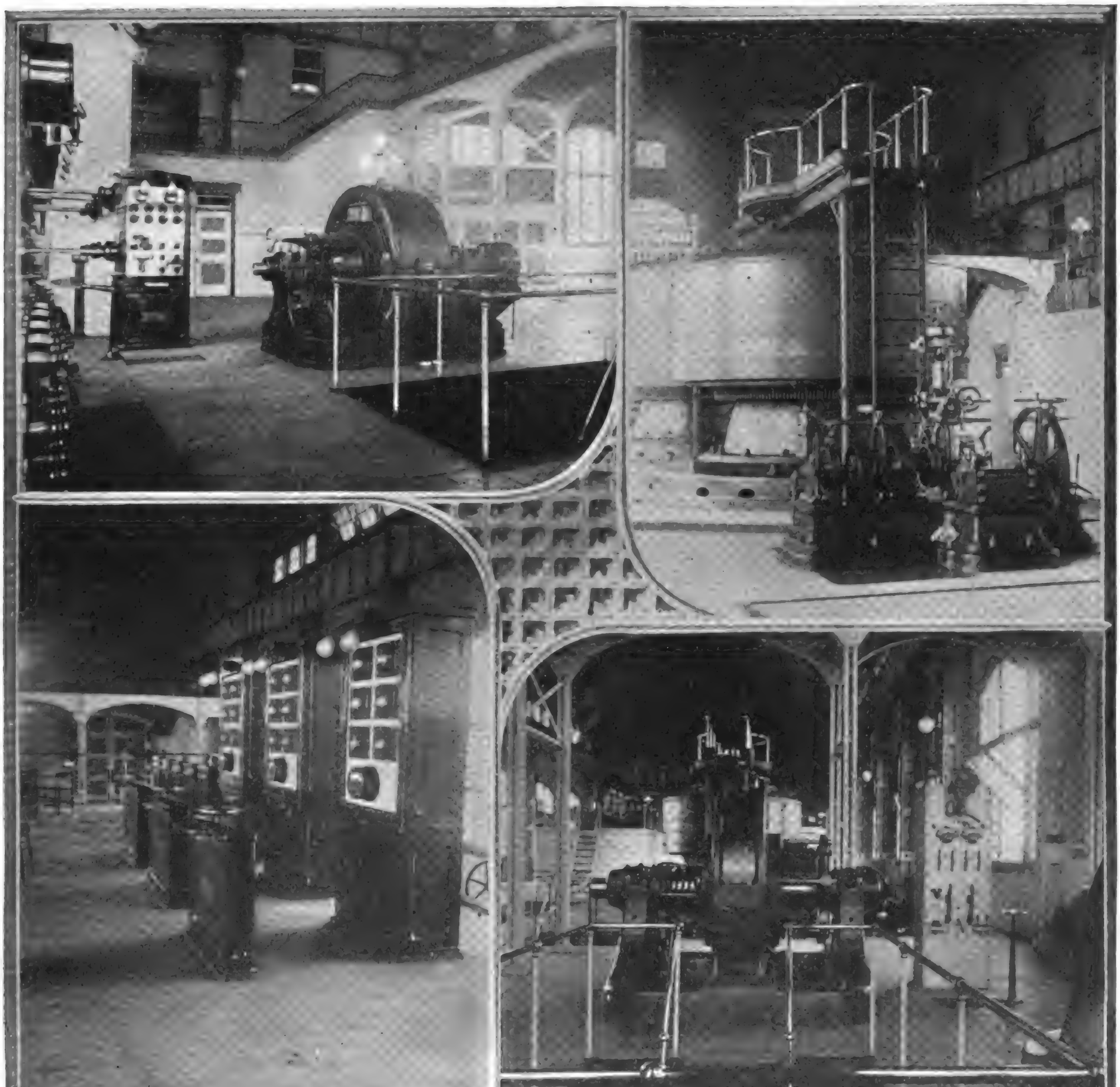


FIG. 1.—WESTINGHOUSE ROTARY CONVERTER.
FIG. 2 —VIEW ON TOP OF SWITCH PLATFORM.
FIG. 3.—TWO-PHASE GENERATOR AND GOVERNOR.
FIG. 4.—GENERAL ELECTRIC ROTARY CONVERTER.

POWER HOUSE—NIAGARA FALLS POWER COMPANY.

of which so much has been said and written; and, second, the Niagara Falls Hydraulic Power & Manufacturing Company's enterprise, of which comparatively little has been published, but which is by no means insignificant.

The Niagara Falls Power Company is to-day operating a plant of 15,000 HP, which comprises a portion of the 50,000-HP-plant originally designed and now being rapidly pushed to completion. The hydraulic arrangements are, with some slight modification, those proposed by Thomas Evershed, in 1843. His idea was to construct a short canal a mile or more above the Falls, which should feed a system of penstocks, the tail-water to be conducted through a tunnel discharging inconspicuously below the Falls. The amount of water deflected from the Falls by the utilization of 100,000 HP he estimated to be less than 4 per cent., which would reduce the thickness of the fall less than 2 ins.

Inasmuch as there has been some outcry as to the danger to the natural beauty of the Falls involved in a large use of power, a few words may not be out of place. The ornamental caption of this article serves a purpose in this respect other than its more obvious one. It consists of a panoramic view of the Falls, in one corner of which is the tunnel outlet. A ready comparison of the volume of water deflected to the volume passing over the Falls may be made, and the most hypercritical guardian of the Falls cannot but admit, on noting this comparison, that any danger is only imaginary.

The water level of the Falls varies quite markedly, and is made a matter of record at the power house by means of a suitable registering instrument. On the inspection of a number of such charts the writer found values ranging from an effective head of 137½ ft. to 135½ ft. The mean ap-appeared to be about 136 ft. This variation is attributed to winds on the lake, high water being accompanied by a high west wind.

FIG. 7.—GENERAL VIEW OF NIAGARA FALLS POWER COMPANY'S GENERATING STATION.

The Canal.—The canal is about 178 ft. long and 12 ft. deep, and when utilized to its fullest extent will develop 100,000 HP. The company owns land on either side of the canal, and thus is at liberty to take water from either side. The gratings, which exclude foreign matter from the penstocks, are of iron. In the winter time, when anchor ice becomes troublesome, a boiler of about 100 HP is called into play. By means of flexible tubing the anchor ice is thawed loose from the grating by a jet of steam and hauled out by long rakes. The water is remarkably clean in summer, when little clearing of gates is necessary.

FIG. 5.—EXCAVATING THE NEW WHEEL PIT.

The Penstocks.—There are ten of these, of which only three are now in use. Four lead to the present wheel pit, and six will supply the turbines which are to be in the new wheel pit, now in course of construction. The penstocks are 7½ ft. in diameter and taper down to this circular dimension from an elliptical section, the major axis of which is some 50 per cent. larger. The penstock tubes are of steel, built into the masonry. A short rectangular fore-bay directs the water from canal into penstocks.

The Wheel Pit.—This is a construction involving long and arduous labor. It is an excavation 30 ft. wide and 180 ft. deep, and sufficiently long to accommodate ten turbines.

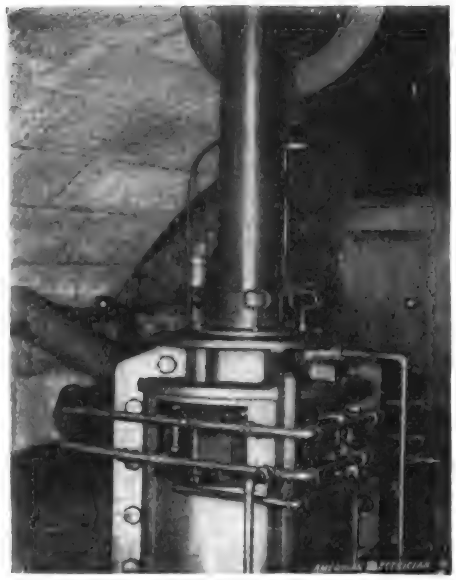


FIG. 6—THE THRUST BEARING.

A better idea than conveyed by mere figures can be obtained by an inspection of Fig. 5. Here the new part of the wheel pit is shown, sunk to a depth of 140 ft., and with 40 ft. further yet to go.

It will be noted that the sides of the pit have a serrated appearance, like the clapboards on a house in an inverted position. This is the work of a grooving machine, which consists simply of a movable steam drill, having a lateral motion as well as one in the direction of its length. This grooving machine cuts a slot 6 to 8 ft. long instead of a hole, and the slot having been made to the depth of a foot and a half, the rock between is broken up and removed and a fresh start made.

The pit shown in the picture will, when complete, require the excavation of over 40,000 cubic yards of stone, at an approximate cost of $3 per cubic yard. It would be impossible to construct a pit of such depth in other than solid rock, on account of the difficulty of shoring the sides.

The Turbines.—It is rather disappointing to the patriotic American engineer to be obliged to say that we were compelled to go abroad for the turbine design for this installation. The exceptional character of the work, and the fact that the designers, Messrs. Faesch & Piccard, Swiss engineers, had been successfully solving similar problems in their native country, must be the excuse.

The turbines are capable of delivering 5500 HP each, and are believed to have an efficiency of something over 70 per cent. They are fed by vertical flumes descending

perpendicularly to the bottom of wheel pit.

The Tail Race.—This consists of two tunnels, one a lateral tunnel at right angles to the other, or main tunnel, which leads to the river below the Falls. These tunnels have been so exhaustively described that a passing reference only is necessary.

The width of the main tunnel is 18 ft. and 10 ins. Its section is an ellipse, with its major axis vertical and flattened at its lower end, and having a section of 386 square ft. The height of the head of the tunnel above the lower river is 40 ft., and this incline produces a velocity of flow of 21 ft. per second, or a little less than 20 miles an hour. The length of the tunnel is 7000 ft., cut through the solid rock. In order to make a smooth raceway it is lined with bricks. It is of statistical interest to note that it required the removal of 300,000 tons of rock, and that 16,000,000 bricks were used in its construction.

The Main Shaft.—Having followed the course of the water to the end of its useful career, we now return to the turbines and trace the path of the power. The turbines deliver their power to a vertical shaft, which consists of a tube 38 ins. in diameter, with ¾-in. walls. At the bearings the shaft becomes solid and reduces to 11 ins. in diameter. The thrust bearing, which prevents the shaft from lateral play, is very like a small thrust bearing on an ocean liner, except that it is vertical instead of horizontal. It is shown in Fig. 6. It is provided with a circulation both of water and oil, but the former is seldom, if ever, used, as the bearings run sufficiently cool with the latter. The thrust of the shaft is minimized by the fact that the upward thrust of the turbines is largely balanced by the weight of the revolving system. It is interesting to note that all of the bearings that are thus fed have the bulb of a thermometer placed in the circulating oil.

The Dynamos.—These are probably the most interesting machines of their class in the world, but for reasons already given, an exhaustive description at the present time would be superfluous.

A cylindrical stationary armature wound with two distinct distributed windings is surrounded by a revolving steel ring, carrying twelve inwardly-projecting pole pieces. This ring is suspended from and revolved by a circular plate, which is keyed on to the vertical shaft, the combination of the last two members being suggestive of a gigantic steel mushroom, of which the shaft forms the stalk.

The output of the generator is delivered to four wires forming two circuits, and passes to the switchboard. The exciting current, which varies from 45 to 90 amperes, according to the load, is led in at the top of the machine by two slip rings, which are the only sliding contacts on the dynamo. The speed of the machines is 250 r. p. m., and the number of cycles per second is practically 25. The working voltage is 2000-2200, at which pressure each machine can deliver two currents of 850 amperes, each differing by 90° in phase. One of the generators is the subject of Fig. 3. When in motion the draught created by the fan-shaped projections on the upper part of the machine is so great that it is difficult to manipulate a camera in its vicinity. The losses of the dynamos, while a very small percentage of the total output, are nevertheless of considerable horsepower, and require ample ventilation to dissipate them, but the above arrangement proves more than adequate.

The Governors.—These are also of the design of Messrs. Faech & Piccard, and in the foreground of Fig. 3 one of them may be seen. A centrifugal governor controls a set of pawls on an oscillating member and causes one or the other to engage with a ratchet, which operates the gates. The device of a nest of epicyclic-bevel gears is utilized to secure a prompt action.

A most interesting feature of the governing of this station is the fact that though each turbine has a governor, only one governor is effective. The alternators run in multiple, and therefore synchronously. Thus, if a governor adjusts the speed of a wheel higher than that of its mates, all the other machines must come to that speed regardless of the dictation of their gov-

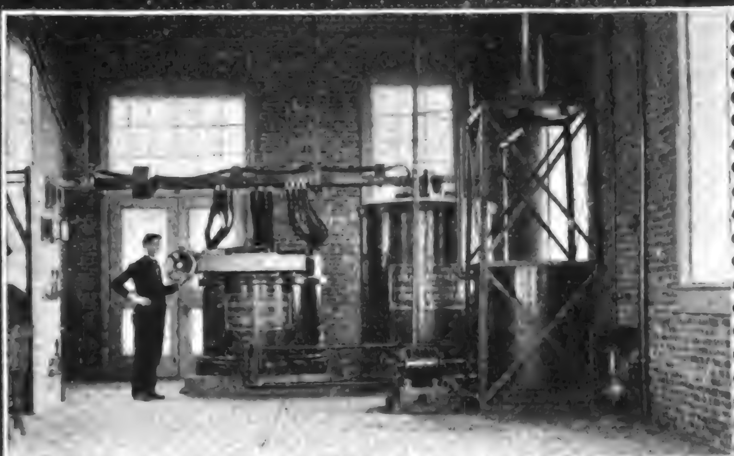
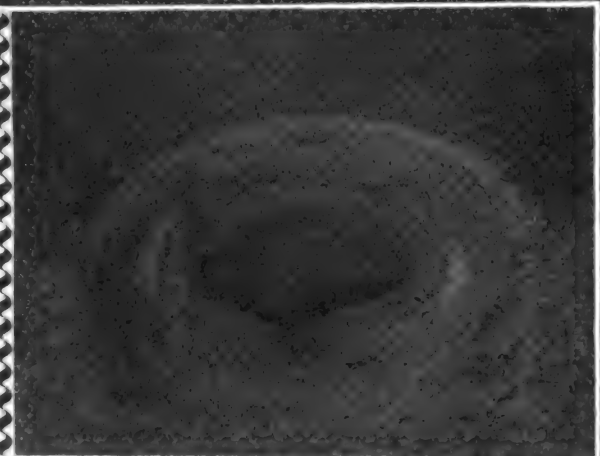



FIG. 8.—TRANSFORMER AND REGULATOR. FIG. 10.—SECTION OF FURNACE.
FIG. 9.—FURNACE AT WORK. FIG. 11.—FURNACE DISMANTLED.

DETAILS OF PLANT OF CARBORUNDUM COMPANY.

ernors. Therefore, the governor that is set to regulate to the highest speed, will operate, and the others will be idle. Inasmuch as it is impossible to set two governors to regulate exactly alike, there will always be one of higher speed than any of its fellows, and will deprive them of their control over their machines. The governors operate by controlling numerous gates surrounding the turbines.

The Control.—An elevated platform contains the switches, and on the top of the platform are the devices controlling them. The switches, which are, of course, very large, are manipulated by compressed air.

There are two complete sets of bus-bars, and any machine, or any circuit, can be switched on to either, or disconnected altogether. The field switches are arranged so that that circuit can be opened through a resistance, which provides a path for the discharge. Each machine has a panel carrying the following instruments:

Synchronoscope, two ammeters, two voltmeters and two wattmeters, or one of each of the latter for each of the two-phased circuits, one direct-current ammeter for measuring the exciting current.

In Fig. 2 is a view of the switching platform, in which one of the measuring panels and the pedestals containing the controlling levers can be seen. Fig. 7 shows a general view of the station.

The Building.—The building is a work of architectural beauty, as well as of utility. It is of limestone, and has an imposing front, while a well-kept lawn surrounds a paved court-yard. A bronze pedestal in the center of the circular yard is surmounted by a flag-pole. The machinery hall is a plain pitch-roof structure traversed by a Sellers crane. The design is such that the building may be readily extended to cover the remaining ten wheel pits without marring its symmetry. The building occupies one side of the canal, which is spanned by a conduit and hallway for the mains passing to the transformer house, which is the center of ramification of the various lines. This house is also built to harmonize with its surroundings.

The Distribution.—The power from this installation is distributed as follows: The Pittsburg Reduction Company takes 3500 HP, from which it realizes 3000 HP in direct current by means of static and rotary transformers.

The Carborundum Company uses 1000 HP, which it reduces in a static transformer to a pressure which can be varied from 250 to 90 volts.

The Acetylene Light, Heat and Power Company was using 1000 HP, transformed to current at 100 volts pressure. It has recently shut down to increase the plant capacity, and will shortly start up again, using 5000 HP.

The Niagara Electro-Chemical Company is using 400 HP, transformed to direct current at 160 volts. The plant has a capacity of 1000 HP.

The Central Power & Conduit Company uses 1000 HP, which is stepped up in the transformer house to 11,000 volts, and at that pressure transmitted to Buffalo. There it is stepped down and transformed to direct current at 550 volts.

The Buffalo & Niagara Falls Electric

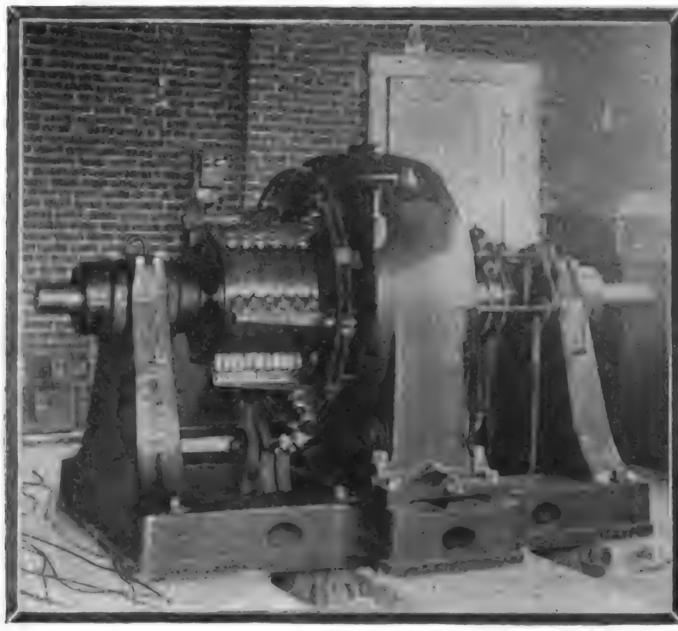


FIG. 12.—ROTARY CONVERTER WITHOUT FIELD WINDING.

FIG. 13.—ROTARY CONVERTER WITH FIELD WINDING.

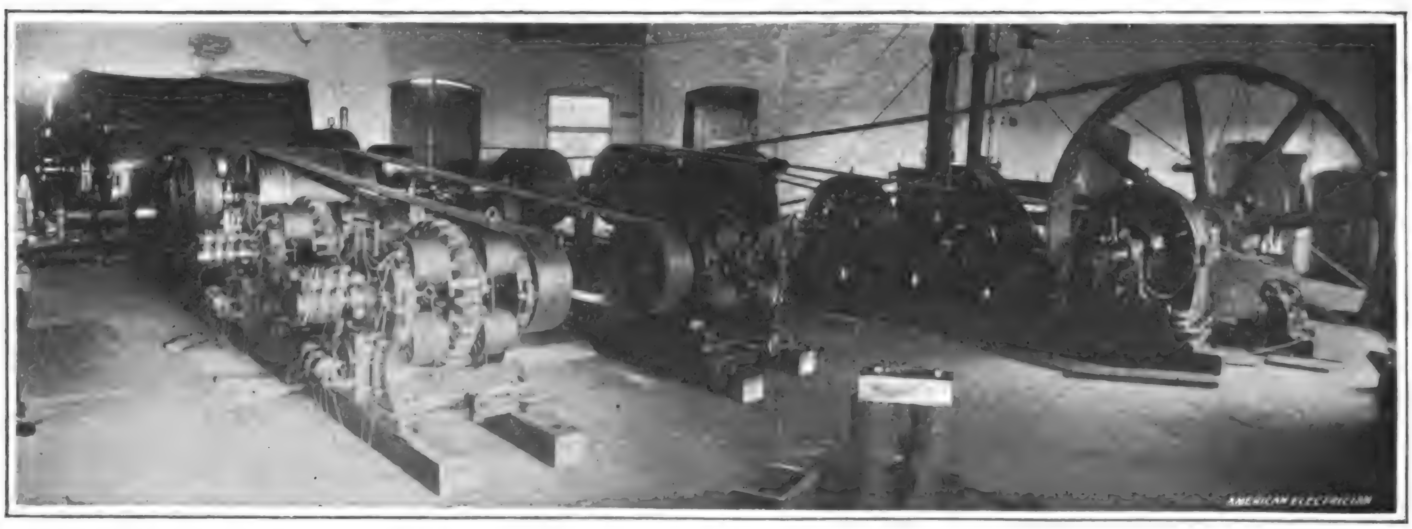


FIG. 14.—STATION OF BUFFALO-NIAGARA FALLS ELECTRIC LIGHT AND POWER COMPANY.

Light & Power Company uses 500 HP of alternating current for lighting the city of Niagara Falls, and 150 HP of direct current for arc lighting.

The Niagara Falls Water Works Company uses 45 HP of direct current at 500 volts, and the Hygeia Ice Company 50 HP at the same pressure. These last two customers are supplied from a bank of rotary transformers at the power house. Figs. 1 and 4 shows two types of rotary converters which are used in this bank, representing respectively the Westinghouse and General Electric Companies.

FIG. 15.—PLANT OF NIAGARA FALLS HYDRAULIC POWER & MANUFACTURING COMPANY.

The prospective users of power are as follows: The Mathiesen Alkali Works, which have just been completed, and in which about 2000 HP will be used; the Albright-Wilson Company will use 200 HP, the Chemical Construction Company will employ 500 HP in producing its goods, and about 500 HP will be used for elevating grain in the city of Buffalo.

General Manipulation.—In such a plant as this it is not necessary to observe the rules of economical loading of machines, for the reason that whatever power is not used from the turbines will pass over the Falls, and nothing will be saved. It is, therefore, better to load each machine as lightly as possible, for durability's sake, for, of course, a heavily-loaded machine gets more wear and tear. As a matter of fact, however, the way the load is distributed makes but little difference, as convenience is the principal dictator as to what machines shall run and what shall not.

The power is distributed to the customers, and as it is mostly used for electric furnaces and similar devices, therefore it by no means follows that the two circuits of each machine will be balanced. As to motors, the higher cost of polyphased apparatus has created a general preference for direct-current motors, which are operated directly from the circuits of the rotary transformers at the station.

The machines are thrown in multiple by means of a Westinghouse synchronoscope, which is a little magnetic affair, the moving parts of which are acted upon by two magnets, one on the secondary circuit of each generator, in such a manner that when the machines are in step the magnetizing influence will be balanced and no deflection of the indicating needle will occur; at this moment the machines may be thrown in multiple, after which it is a practical impossibility to get them out of step.

The excitation of the generator is accomplished by means of a small rotary transformer driven from the two-phased circuits. The station would be in rather an awkward predicament if everything should shut down, were it not for the fact that a small dynamo in an adjacent building is available as a starter, and once started the plant again becomes independent. The proposed installation of four exciters with a separate turbine will do away with any such necessity.

The half-hourly record which is made on the log book comprises the watts, the volts and the amperes of each of the two-phased circuits, the temperature of the bearings, the exciting current and other important data. The water level is automatically registered and measured. The field circuit on the machines is provided with a special switch, by means of which the discharge takes place through a resistance, and is thus prevented from puncturing the insulation or causing a bad arc at the switch. The feeders are provided with derived circuits which actuate the recording wattmeters, and therefore each customer pays for his own line loss.

The Carborundum Company.—This company takes power from the Niagara Falls Power Company to the extent of 1000 HP. This is received in a transformer, which converts it from 2200 volts to a pressure of 250 volts, and by means of an enormous reactive coil the latter can be controlled from the maximum down to 90 volts.

These two large pieces of apparatus are shown in Fig. 8, and their great size will at once be noted. The losses of these machines are extremely small in proportion to their output, but their great size makes the actual amount of horse-power wasted quite large and sufficient to cause considerable annoyance by heat, were it not that oil is continuously circulated in both members by a little pump.

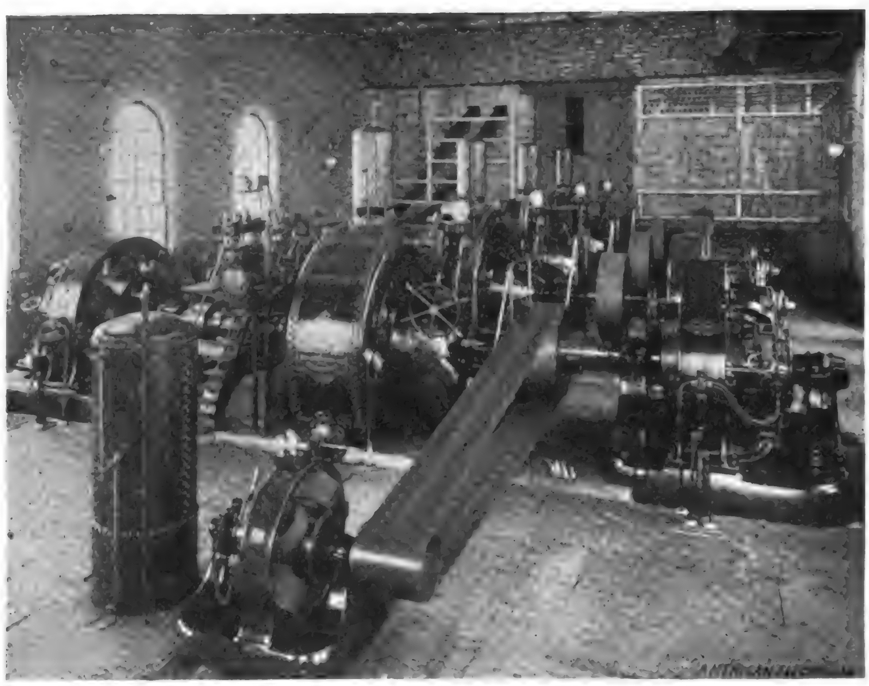


FIG. 16.—GENERAL VIEW OF GENERATING ROOM OF NIAGARA FALLS HYDRAULIC POWER & MANUFACTURING COMPANY.

Two massive bus-bars carry the current to the furnace room, where it is used in the manufacture of carborundum. This material is a silicate of carbon, and is extremely hard, much harder than any substance except the diamond. It is produced by sub-

jecting its constituents to an enormous heat, in what is known as an incandescent furnace. Such a furnace is shown in Fig. 11. The ends contain each a bunch of 60 carbon rods 30 ins. long and 3 ins. in diameter; the ends of these rods are each drilled with a little hole, carrying a plug, which is a portion of the large bronze plate to which the cables are attached. Two such terminals are placed in either end of the furnace, which is then built up of loose brick, no mortar being used.

The mixture which unites with coke to form carborundum, consists of salt, sawdust and glass sand, mixed in certain proportions. The furnace is filled rather more than half full of this mixture. A semi-circular trench is then hollowed out, the axis of which coincides with a line drawn between the centers of the terminals in either end of the furnace. A core of coke, which is cylindrical in section, is built in and bridges the space between the two terminals. Each furnace requires about 1100 lbs. of new core—that is, fresh coke—or 850 lbs. of core which has already been used in a furnace. A complete cylinder is about 21 ins. in diameter and 14 ft. long. Substantial contact is made with the carbon terminals by packing the coke tightly in among the rods previously mentioned. The core being complete, the mixture of sawdust, salt and sand is thrown into the furnace and heaped high above it, the total height being about 8 ft. The furnace is then ready for the electric current.

The current is applied at the maximum voltage at first; if the furnace has been built with new core the amount of current taken is quite small at first, but if old core has been used it almost immediately reaches a value of 1,200 amperes, due to the greater conductivity. The voltage is then increased until a sufficient current flows to make the core quite hot, and as it heats its resistance diminishes, so that finally the voltage has to be reduced. Presently the furnace resistance becomes a fairly constant quantity, and having once adjusted the current to the proper value, further regulation is usually unnecessary. For about an hour no apparent change is noticeable in the furnace, but after a certain time gaseous products begin to ooze out from between the bricks and take fire.

About 5½ tons of gas are given off during the reaction. Fig. 10 shows such a furnace at work, and also serves to give an idea of its construction. At the end of 4 or 5 hours the top of the furnace begins to gradually subside and cracks open on its surface, from which pour out flames tinged yellow by the sodium contained in the salt. If the furnace has not been built up in a very porous shape it is liable to explode at this juncture, scattering large amounts of the mixture in all directions.

A fissure will sometimes suddenly open in the top of the furnace and a roaring pillar of flame several feet high arise; and it is then necessary to cut off the current altogether and allow the furnace to cool. The mixture is then removed to a depth of about 2 ft., and the blow-hole is removed and the cavity filled up with fresh mixture. The sawdust is added to the mixture for the purpose of avoiding this "blowing," as it is termed by the workmen.

At the end of about 24 hours the process is completed, and the furnace is allowed to cool, which takes several hours. Then the sidewalls are taken down and the outer unchanged mixture is removed, thus exposing around the core an outer crust of amorphous carborundum. This crust can be easily peeled off from the inner crust, which is also amorphous carborundum, but in a more powdered form. This is removed with a spade, and the crystalline carborundum surrounding the core is next exposed. This is a most beautiful compound, and wherever there is a hollow and the crystals have had opportunity to form they are remarkably large, sometimes measuring ½ in. on the side.

A section of the furnace (See Fig. 10) shows first a crystalline core of carborundum; second, a surrounding mass of amorphous carborundum in a light greenish powder, and third, the crust of amorphous carborundum. The dividing line between this crust and the unchanged mixture is very abrupt. Mixed in with the core is some carbon in a graphitic form. The amount of graphite depends upon the temperature at which the furnace is operated, and too high a temperature produces it in considerable quantity. The crystals of carborundum are broken up fine, washed in diluted acid to remove their impurities, sifted through sieves of various finenesses and sorted in bins, according to the number of meshes in the sieve. They are subsequently moulded with a suitable binding material into wheels, slips, rods and polishing paper and similar tools and materials for grinding. The substance is so hard that it is said to do many times the work of either emery or carborundum, and though more expensive than either, is largely used in preference.

The Pittsburg Reduction Company.—This company has two plants at the Falls, one of which receives its power from the Niagara Falls Power Company, and the other from the Niagara Hydraulic Power & Manufacturing Company. That of the former company is located a short distance from the power house and consumes about 3500 HP, delivered at the power house end of the line, and 3000 HP is available in direct current at the terminals of the rotary transformers.

This current is used in producing aluminum from its oxide. A carbon-lined retort in which a carbon pencil is suspended forms the apparatus in which the reaction takes place, the retort itself and the suspended pencil forming the electrodes. The current is usually at a pressure of about 160 volts, and 60 retorts are placed in series. The aluminum oxide, combined with a suitable flux, is placed in the retort, and the combination of immense heat and electrolytic action causes the aluminum to be reduced from the mixture. This reduction by means of carbon is a popular method in use for reducing all metals, but it does not take place in the case of aluminum except at this enormously high temperature. The static transformers each receive current from the line, transforming from 2200 to 115 volts, and on passing through the rotary converter the issuing direct current has a pressure of 160 volts. The joint capacity of the converters is about 10,000 amperes.

The Niagara Electro-Chemical Company.—This company uses about 400 HP in direct current at 160 volts. Its total capacity in rotary converters is 750 KW, comprised in three machines of 250 KW each. The static transformers receive current at 2200 volts and step it down to 115 volts, while the rotary transformers raise it to 160 volts, then transform it to direct current.

The rotary converters are of two types, one of the ordinary design with wound pole pieces, and the other of the induction type, the pole pieces of which carry no

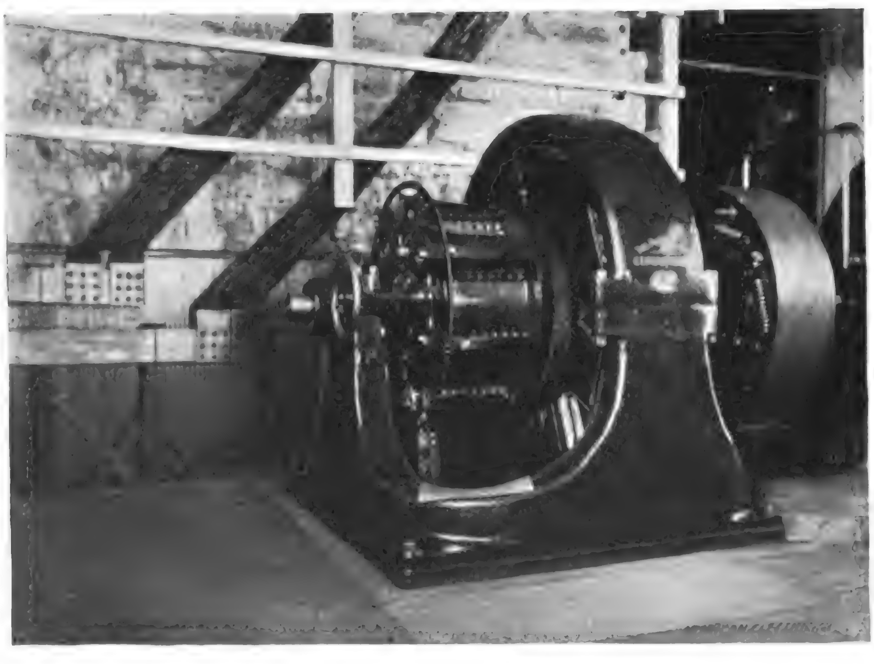


FIG. 17.—GENERATOR, PITTSBURG REDUCTION COMPANY.

windings. A rotary converter, it will be remembered, does not depend upon the strength of its field for the control of its voltage, and it is really more of a commutator than a dynamotor. The effect of the strengthening the field of a rotary converter is a condenser effect on the line which compensates for the inductive drop, and can even produce a leading current, which is sometimes desirable. The converter which works without field windings has the advantage of being somewhat easier to start and is cheaper to manufacture, although it is but justice to say that the other converter can be started in exactly the same way by simply opening its field circuit. This induction converter is said to be the first to be commercially used.

The induction converter is started by interposing a choke coil in the two-phased circuits in the armature. As the surrounding pole pieces have no polarity, there is no need of waiting to obtain synchronism, for in the endeavor to complete the magnetic circuits of its armature the latter will revolve. The other converter can be started up in the same way, but when a synchronous speed is attained it is necessary to be careful to throw in the field circuit so connected that the armature flux and the field flux will work harmoniously. Figs. 12 and 13 show two types of converter used at this installation.

Current is used in this plant almost entirely for the manufacture of sodium, which is electrolytically produced by the decomposition of sodium hydroxide, or ordinary caustic soda. Thirty electrolyzing pots are used in series. Sodium is produced in these works not so much for sale as for use in manufacturing other reagents. Among these is peroxide of sodium, which is largely replacing peroxide of hydrogen as a bleaching agent.

The Acetylene Light, Heat & Power Company.—The progress of this company will be of more than usual interest to electric light engineers, and thanks to the management some very interesting data have been furnished. As is well known, acetylene is a gas produced by the combination of carbide calcium and water, and is used for lighting houses, heating and power in the same way that ordinary illuminating gas is used. As the claims of its manufacturers have been widely spread, and the foundations for them have been fully detailed on this part of the subject we will not dwell.

The problem of the manufacture of its essential component, carbide of calcium, as a commercial article, and at commercial prices, is the principal object of interest. The plant of this company had been operating for some time, consuming about 1000 HP, but it has been largely increased, and 5000 HP will be shortly available. This power is transformed in five 1000 HP transformers, three of which are of the General Electric make, and the remaining two are Westinghouse products. They receive current at 2200 volts and transform to 100 volts.

It has been customary to use a choke coil on the secondary circuit, but it is found that this is not necessary, and that the current can be amply regulated by varying the distance between the terminals in the arc furnace.

This furnace is an interesting affair. A little alcove is built in a brick structure into which a little truck is run, the bottom of which is of iron and removable. A heavy iron lug is cast on one end of the truck, and when it is run in place in the alcove it is securely bolted to the corresponding plate, which is connected to one terminal of the transformers. The top sides of the truck are of sheet iron.

In the center of this truck is hung a large carbon rod, which is suspended from a wire rope, passing over pulleys to the controlling room. A diagram of this furnace is shown in Fig. 19. This carbon rod, which is of the most liberal dimensions, is lowered into the iron receptacle until it touches the bottom, and is then drawn away, pulling an arc after it, which carries 2500 amperes at 100 volts. This arc is often 13 ins. long, and the frequency of alternation is so low that it produces a deafening roar. Little chutes are then opened on either side of the truck and the component mixture falls down into it, and is subjected to the heat of the arc.

This mixture consists of ground coke and lime in the ratio of about 40 to 60 per cent., respectively. When subjected to the influence of the arc a button of calcium carbide quickly forms on the bottom of the truck, and gradually increases into an ingot, the carbon rod being drawn up as the button increases in size, until the truck is full. This ingot weighs about 700 lbs., and is surrounded by about 2 ft. of unchanged mixture, which is taken out, sifted and sent back to the conveyors which supply the furnaces. These conveyors and the other machinery about the works are driven by two two-phased, 75-HP General Electric motors.

The carbide is broken into small lumps and packed in iron drums, which hold about 500 kilos., and in 100, 50 and 10-lb. packages.

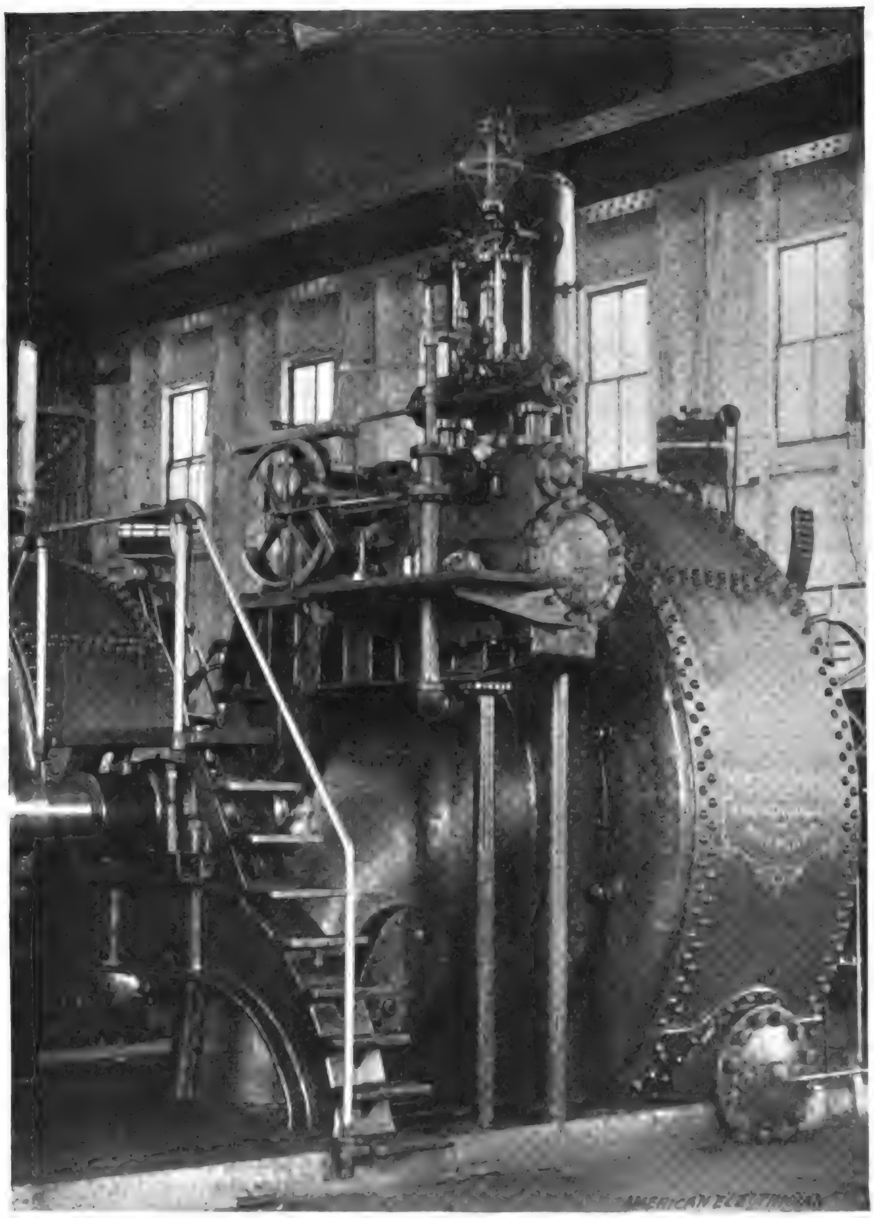


FIG. 18.—TURBINE AND GOVERNOR.

The time for forming an ingot takes from five to seven hours, according to the amount of current used. The regulation of current for each furnace is accomplished

entirely in the regulating room, and the operator never sees the furnace itself; he simply adjusts the current to the constant value by raising or lowering the carbon rod, and he has the ammeter before him for guidance.

The alternating currents which are used are of such great volume that the inductive

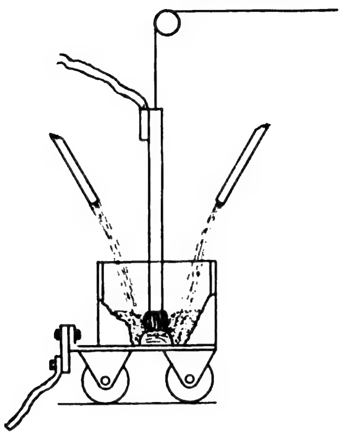


FIG. 19.—DIAGRAM OF CARBIDE FURNACE.

drop on even these short lines is very important and of no inconsiderable magnitude. For this reason the leads are of heavy flat strips and are interlaced; that is, alternate positive and negative leads are placed in a common bunch, passing upward to the bus bars, and this interlacing construction is carried as far as the furnace. It is noteworthy that this industry has been built up in nine months, and that these extensive works have been constructed in very much less time. The president of this company, Mr. C. C. Adams, and the treasurer, Mr. Edw. C. Naphyes, are largely responsible for the commercial success of the product so far, and to Mr. Jos. P. Devine, the manager, is due the credit of having modeled the works and directed their management in such a way as to produce calcium carbide as a commercial commodity.

The Niagara-Buffalo Transmission.—The length of this line is 27 miles, and over it is transmitted about 1000 HP at a voltage of 11,000. On all but about 4000 ft. the power is transmitted over bare wires, mounted on heavy porcelain triple-petticoat insulators. These insulators depend for their dielectric properties largely upon the excellent quality of the procelain of which they are made. Each insulator weighs something over 12 lbs. It is provided with gutters on the outer petticoat to deflect the water, so as not to drip on the cross-arm. A great deal of trouble was experienced in obtaining the proper insulator for use in this work, and the one just described was finally selected after many others had been tried and failed. The successful product was that of the Imperial Porcelain Works, of Trenton, N. J., and they are entitled to no little credit for the complete satisfaction that their insulators have given in service.

The power is stepped up by a Scott transformer system, and converted from two currents, at 90° apart, to three currents, with 120° difference of phase, and is so transmitted to Buffalo over three wires, each of which has a cross-section of 350,000 CM. It is composed of nineteen No. 8 wires. The line is run on poles about 100 ft. apart, and each pole is stenciled "dangerous," as indeed it would be should one of the insulators upon it get broken, but under ordinary circumstances it is perfectly safe. The inductive drop is about 10 per cent. The last 4000 ft. of line consists of lead-covered cables, which are run along the edge of Erie Canal in board troughs. The repairs which are now being made on the canal, and frequent cavings along the edge have done much to interrupt the service, but these difficulties have been so marvelously well met by the high insulation of the line that its performance must be considered as a very creditable one, and plainly shows that transmission at double the voltage is a practical possibility. Indeed, it is contemplated doubling the working voltage in the near future, and the transformers are so wound that a change in connections will be all that is necessary to do this.

The power is stepped down by static transformers, and then through rotary transformers is converted into 500-volt direct current, and used on the Buffalo Street Railway lines. Over this line, when complete, it is proposed to transmit much more power for local purposes about the city of

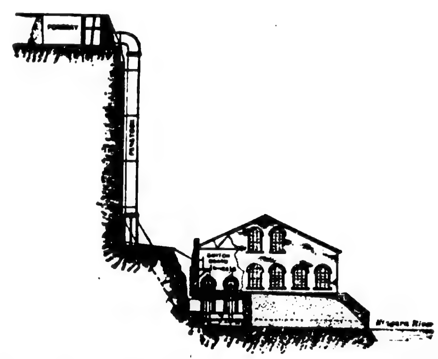


FIG. 20.—CROSS SECTION OF POWER HOUSE OF NIAGARA FALLS HYDRAULIC POWER & MANUFACTURING COMPANY.

Buffalo, but the constant annoyance that has been experienced by disturbances of the lead-covered cable system have made the Central Power & Conduit Company, which operates the line, rather loath to contract for power until it can guarantee a more uninterrupted service.

The Buffalo-Niagara Falls Electric Light & Power Company.—This company operates two stations, the first of which, shown in general view in Fig. 14, was the original lighting station of Niagara Falls city, and formerly run by steam, the original engine showing in the right of the picture. It is now replaced by two two-phased induction motors of 300 HP each, operated from the Niagara Falls power station. These motors, which run at a speed of 500 revolutions per minute, drive a jack-shaft, which is divided into two parts by a friction clutch, and from this shaft are driven three alternators and three 125-light Brush arc dynamos. It may be asked why the alternating power is not used directly from the Niagara Company's mains, and the losses of transformation thus saved. But the transformer plant of this company, being built for 15,000 alternations per minute, is entirely unsuitable for the 25-cycle current, and the extreme cheapness of power will render the amount of saving so small that the large first cost obtained by the necessary change to use 25-cycle current direct would not be justified. The operation of this plant has been very continuous, and since the motors were installed it has never been necessary to use the engine.

Another branch of this plant is installed in the building of the Cliff Paper Company, which is located on the brink of the precipice, abutting the lower river, and consists of two monocyclic generators directly driven by a turbine supplied from the hydraulic canal of the Niagara Falls Hydraulic Power & Manufacturing Company. Although somewhat limited as to space, the plant is well arranged, and is a thoroughly modern installation.

The Niagara Falls Hydraulic Power & Manufacturing Company.—This company is a powerful rival of the Niagara Falls Power Company, and though but little has been heard of it, it possesses an extremely interesting plant, which has been constructed under plans representing the very highest engineering talent. The power is received from what is known as the hydraulic canal, which is 100 ft. wide, 18 ft. deep, and reaches from above the Falls to a place on the precipice below them, adjoining the works of the Cliff Paper Company. This canal is of many years' standing, and from it various taps have been made, supplying small industries in the locality with power. The general view of the precipice, given in Fig. 16, shows the sluices of these various plants to good advantage, and most of them, it will be noticed, utilize but a very small fraction of the total head available.

The principal industry utilizing this canal, and which is the subject of this section, gets its power from a fore-bay, which leads into a penstock 7 ft. in diameter and, descending to the foot of the precipice,

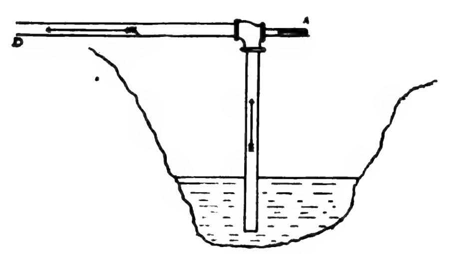


FIG. 21.—HYDRAULIC INJECTOR.

feeds four turbines in the power house at the base under a head of 210 ft. This arrangement is shown in cross-section in Fig. 20. The pressure in the penstock at the base is about 85 lbs. to the square inch, and to resist this pressure 7/8"-mild steel is used in this construction. The joints are double-riveted lap joints, and the penstock as a whole is built with even more care than a well-made tubular boiler. As a precautionary measure, each turbine is supplied with a liberal air chamber, and there is a

large air chamber at the end of the penstock (Fig. 16), which may be seen in the general view; a number of safety valves complete the safety device. The pressure in the penstock is used to manipulate the gates that shut down the water-wheels, and to move the piston of the governor gates.

The turbines were manufactured by the James Leffel Company, of Springfield, O., and it is gratifying to note that in this case the designers did not deem it necessary to go abroad for turbines to operate under an even greater head than those of the Niagara Falls Power Company. On each end of the shaft of these four turbines is a direct-current generator, making eight generators in all. Six of these machines are used to generate current at 300 volts for the Pittsburg Reduction Company. The turbines driving the Pittsburg Reduction Company's machines are of 1700 HP, and the remaining turbines are of 1900 HP, in each case with three-fourth gate, and it can be easily seen that the turbines could be forced to a greater power, as a matter of fact, to a maximum of 2000 and 2500, respectively. The current of the Reduction Company's machines, which, by the way, are of the Westinghouse make, is delivered to two enormous bus-bars, and transmitted up the precipice by two cables, each consisting of 250 No. 000 aluminum wires. These cables pass up a wooden-wire tower to the works of the Pittsburg Reduction Company, on the brink of the precipice. One of the machines of the Pittsburg Reduction Company is shown in Fig. 17, and a view of the bus-bars and the wire cables can also be seen in the same engraving.

The speed of all of the machines is about 300 revolutions per minute. The Pittsburg machines are governed entirely by hand; the field rheostats are not touched, but the opening of the wheel gate is varied by a lever. The machines are thus governed in pairs, and each must be adjusted to equality. The fourth turbine generator, of 500 volts pressure and 560 KW, is of the General Electric make. The speed is controlled by a Lombard water-wheel governor, which adjusts the speed within 2 per cent. See Fig. 18. One of these generators supplies railway current to the Gorge Road (200-500 HP), and to the Lewiston & Youngstown road (70-200 HP); on the latter road the maximum transmission distance is 16 miles. The other 500-volt generator supplies a metallic circuit with about 300 HP for local purposes. On the feeders on the Youngstown road is placed a booster which will boost the voltage to a maximum of 250 volts, the machine being belted to the turbine shaft, as shown in the foreground of Fig. 16, which is a general view of the station. The station is a substantial building, without pretensions to anything but utility. It is spanned by a 100-ft. crane.

An addition to this plant has been for a long time contemplated, and is now being actually installed. It will contain five turbines of 2000 HP each, arranged in a similar way and adjacent to the present plant.

It is interesting to note how the energy of the hydraulic canal is being compelled to construct its own station. Compressed air supplied by compressors operated by turbines, provide the drills and channelers with motive power. The hoisting is all done with hydraulic power as the prime mover. An ingenious injector pump, shown in Fig. 21, serves to keep the excavation free from water. Pressure from the flume is supplied to the pipe *A*, and by its injector-like action forces the water up and out through the nozzle *D*.

The new flume to supply these five turbines is to be 11 ft. in diameter, and is to be built of 1¼-in. steel. It is expected that the machines will be three-phase alternators, but what is to be done with this 10,000 HP is not generally known. However, it is not to be assumed that a management which has thus far shown such marked commercial ability is going to increase the capacity of its plant with any chance of a considerable portion of it remaining idle.

THE LINE EFFECTS IN ALTERNATING-CURRENT TRANSMISSION.

BY H. E. RAYMOND.

In designing and laying out the transmission line for an alternating-current transmission, all calculations must be based upon the individual requirements of the case. Rules and formulas for the calculation of the size of wire and the best voltage to use are to be found in many recent publications, and will not be discussed here. Some "line" incidents resulting from some of the most prominent of the so-called "effects" may, however, be new and sufficiently interesting to pay for their recital.

Generally speaking, the prevalence of the induction, electrostatic and capacity stresses of a line increases greatly with its length, and under certain conditions causes very formidable troubles. The troubles from the line inductance may be readily overcome or practically prevented, and probably capacity causes but slight inconvenience unless the line is very long and other conditions are peculiarly favorable.

In our experience, the most serious and troublesome effects have been those due to electrical resonance. It has been found that for every line there is a certain natural period of wave oscillation, just as there is in a bridge or floor, and if this electrical oscillation is such that the machine frequency will coincide with it the resultant vibration may raise the actual voltage to an alarming extent.

One instance of this was called to mind in a three-phrase line four and one-half miles long, operating at between 2500 and 3000 volts. At 2500 volts it was the custom to test, at stated intervals, each line for grounds. This was done by simply grounding each line separately and singly through a high resistance coil with a lamp in shunt with the proper number of turns. If the lamp was out or very dull on one wire and bright on the others of the circuit, it indicated a ground or leakage on the wire connecting with that which showed the dull lamp. In order to test the line for certain of these effects, and in order to ascertain the value of a coil of wire as a choke to a discharge of lightning, a small air gap, in series with a fuse, connected one line direct to earth on the machine side of the choke coil.

It was expected, of course, that if the coil was of much value the discharge from the line would pass through the lightning arresters on the line side of the coil, and that none would take place across this air gap, even though it were slightly shorter than the gap of the arresters. It was found, however, that although these coils offered some resistance to the discharge, sufficient stress was caused on the gap side of the coil to start a discharge across the gap and blow the fuse. As this gap was connected directly to the earth, it is obvious that when the lines were tested for grounds, and with no current passing through the ground detector, there was a potential of 2500 volts across this gap.

It was almost invariably the case, under these conditions, that the gap broke down and a small arc continued across it as long as the ground detector was in the circuit. The current in this case was, of course, limited by the inductance and resistance of the detector coil. If a ground or any leaks were formed on one of the other wires, the gap would, in the same way, break down, but the fuse would blow, because there was nothing definite in that case to limit the quantity of current through it.

It would appear perfectly natural that this gap should act in this way under such conditions, but the space was found afterward to be too great for 2500 volts to jump, and, on repeated tests, showed that a pressure of from 3500 to 3700 volts was required to break it down. This rise in actual over the indicated line voltage was of course quite small as compared with what might have occurred, but it was sufficient to cause serious inconvenience, to put it in the mildest manner.

It is obvious that the duty of a lightning arrester is to relieve the line of any unusual electrostatic stress, and to divert from the machine any severe discharge of atmospheric electricity that may occur. It is also evident that the arrester in the performance of these duties must also prevent the formation of an arc and the passage of the line current to the ground. This latter tendency has been a decided difficulty, but probably is to be overcome by the insertion of resistance in the ground connection of the arresters and by the use of non-arcing electrode. This resistance to the current, if properly made, offers but a slight obstacle to the static discharge. It offers some, however, and compensation for it should be made in the air gap. Generators, and, in fact, all apparatus directly connected to the line, are, of course, insulated according to the pressure in volts they are to carry, and this insulation is designed to withstand a certain increase in pressure without damage.

Let us suppose a machine is wound for 2700 volts and tested to 5000 volts, the maximum indicated increase to be no more than 3000 volts. With resistance in the arrester circuit, it would be permissible to have the arresters so set that 3,500 volts would break down the gap and no unusual pressure allowed to reach the machine to puncture or strain the insulation. We find,

though, that resonance is going to raise our actual stress to 4500 volts or over, and if a continual discharge is not to pass the arresters the gap must be increased until no spark will jump it under ordinary conditions. If the total insulation strain of any static stress could be confined to the line between the arresters this would probably work all right, but it is very apparent that when an electric storm causes an increase in the static strain on a line the increase extends not from gap to gap, but from end to end, and all portions are more or less affected. If this increase is instantaneous, as it often is, the actual stress on the insulation, before the gap breaks down, may be sufficient to break down also and burn out an armature.

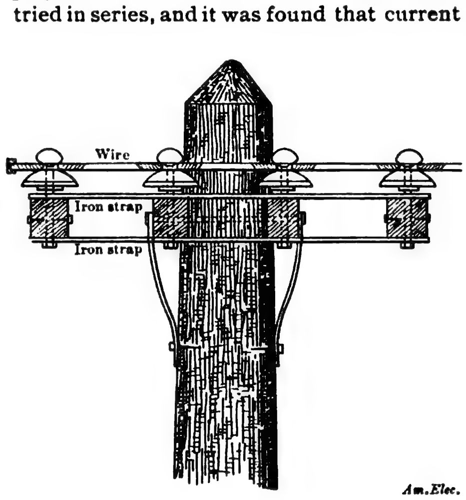
If instead of a gap requiring 4500 to 5000 volts to rupture we could use one requiring but 3500 volts, we would possess a path to earth that would, during times of atmospheric charge, keep our line continually discharged, and nothing but a direct stroke of lightning need be greatly feared, and one that, were there no resonance to increase the total line pressure, would be too great for the ordinary impressed line voltage to jump. This would keep the strain down to practically 3500 volts, and even if a sudden increase occurred it would offer such a low resistance to static stress that the tension would begin to lessen before it had fairly started to raise.

In his "Electric Power Transmission," Dr. Louis Bell speaks of the insulation of the line, giving it as his opinion that insulation on the wires themselves is practically useless for overhead work. For underground the conditions change greatly and, of course, the highest grade of rubber insulation is necessary. The only real use of overhead line wire insulation is in the protection of the line from falling branches and trees. If this is absolutely necessary—that is, if trees cannot be cut—we find that nothing but the best rubber, with a strong covering to prevent mechanical injury, is of much use. If it can be done, cut the trees and cut them well away from the line. It would probably be cheaper to make a considerable detour than to try to insulate the wires so as to render them safe against short circuits and grounds.

We have seen twigs drop across heavily W. P. insulated wires with but 2500 volts across them and start an arc that at once burned the wires off. This was with 10 inches between the wires. On dry days and with dry branches little trouble has occurred with wire bare or covered wire; but if the weather is damp or the trees are wet it will be but a short time before the wire or the tree is burned off, and unfortunately it is generally the wires.

We remember one instance in which a tree fell, and brought two of these wires into contact. They remained all right for a short time, but in a few minutes the villagers below thought the sun was rising again. The insulation was triple braid, very heavy and saturated with some good "weather-proof" compound. The insulation kept the copper in the two wires ¼ inch apart, but in every case that occurred it was but a moment or so before the two wires "arced over" and melted off.

So much has been said regarding the type and nature of the pole insulators to use that comment would be superfluous. A few hints regarding the dead-ending of wires may be of more use. When the installation of alternating-current power-transmission systems was first begun, the insulation of the line was deemed very simple. This was due, of course, to the moderate voltages employed. On the line of one of these installations circumstances made it most convenient to dead-end the lines at five places. This was done in the way that railway feeders usually are, by using strain insulators. These looked very well, but, it was soon developed, were not sufficiently insulated to withstand even the voltage employed, which was 2500 volts. Two were tried in series, and it was found that current



POLE FOR DEAD-ENDING HEAVY LINE WIRES WITH HIGH POTENTIAL.

in considerable quantity would leak through four in series with 12 inches of spruce cross arm. It was then decided to throw these out and use regular cross arms and iron pins with petticoat insulators.

A double cross arm was found strong enough for wires up to No. 0, and for the larger wires, No. 0000 cable, four oak cross arms were set on the end poles and the strain distributed on four pins. A very convenient way to set the arms is to bolt two to the pole, steadying with angle braces, and to bore pieces of iron one-quarter inch by 3 inches, so that the pins can be set through these and the cross arms to be held apart, as in the accompanying sketch.

Regarding the advisability of having more than one line it would be difficult to judge. If the continuous operation of the system was of great importance, and if the cost of a shut-down were great, while the power transmitted was considerable, it seems to us that two lines would be advisable, if the country and climatic conditions were unfavorable. If the cost of the extra line would not be justified by saving the expense of an occasional shut down, it certainly seems advisable to so arrange the line that all the wires in service could be on one side of the arm, and at such distance from the pole that a man could with some safety work on the other side. Even in this case it would be well for the linemen to organize a mutual life insurance company, for should a wire break while being strung, very serious consequences would likely occur, both to climbers and ground men.

DROP IN ALTERNATING-CURRENT LINES.

BY RALPH D. MERSHON.

When alternating currents first came into use, when transmission distances were short and the only loads carried were lamps, the question of drop or loss of voltage in the transmitting line was a simple one, and the same methods as for direct current could without serious error be employed in dealing with it. The conditions existing in alternating practice to-day—longer distances, polyphase circuits and loads made up partly or wholly of induction motors—render this question less simple, and direct-current methods applied to it do not lead to satisfactory results. Any treatment of this or of any engineeering subject, if it is to benefit the majority of engineers, must not involve groping through long equations or complex diagrams in search of practical results. The results, if any, must be in available and convenient form. In what follows the endeavor has been made to so treat the subject of drop in alternating-current lines that if the reader be grounded in the theory the brief space devoted to it will suffice, but if he do not comprehend or care to follow the simple theory involved he may nevertheless turn the results to his practical advantage.

Calculation of Drop.—Most of the matter heretofore published on the subject of drop treats only of the inter-relation of the E. M. F.s involved, and, so far as the writer knows, there have not appeared in convenient form the data necessary for accurately calculating this quantity. The table and chart given below include in a form suitable for the engineer's pocket-book everything necessary for calculating the copper of alternating-current lines.

The chart is simply an extension of the

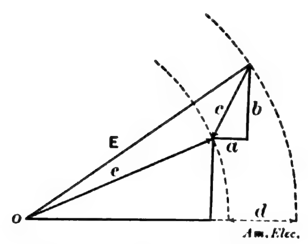


FIG. 1.—VECTOR DIAGRAM.

vector diagram (Fig. 1), giving the relations of the E. M. F.'s of line, load and generator. In Fig. 1 E is the generator E. M. F.; e the E. M. F. impressed upon the load; c that component of E which overcomes the back E. M. F. due to the impedance of the line. c is made up of two components at right angles to each other. One is a, the component overcoming the CR or back E. M. F. due to resistance of the line. The other is b the component overcoming the reactance E. M. F. or back E. M. F. due to the alternating field set up around the wire by the current in the wire. The drop is the difference between E and e. It is d, the radial distance between two circular arcs, one of which is drawn with a radius, e, and the other with a radius, E.

The chart is made by striking a succession of circular arcs with o as a centre. The radius of the smallest circle corre-

sponds to *e*, the E. M. F. of the load, which is taken as 100 per cent. The radii of the succeeding circles increase by 1 per cent. of that of the smallest circle, and, as the radius of the last or largest circle is 140 per cent. of that of the smallest, the chart answers for drops up to 40 per cent. of the E. M. F. delivered.

The terms resistance-volts, resistance-E. M. F., and reactance-volts, reactance-E. M. F., refer, of course, to the voltages for overcoming the back E. M. F.s due to resistance and reactance respectively. The figures given in the table under the heading "Resistance-Volts for One Ampere, etc.," are simply the resistances of 2,000 feet of the various sizes of wire. The values given under the heading "Reactance-Volts, etc.," are, a part of them, calculated from tables published some time ago by Messrs. Houston and Kennelly. The remainder were obtained by using Maxwell's formula.

The explanation given on the sheet itself is thought to be a sufficient guide to its use, but a few examples may be of value.

Problem:—Power to be delivered, 250 KW; E. M. F. to be delivered, 2000 volts; distance of transmission, 10,000 feet; size fo wire, No. 0; distance between wires, 18 inches; power factor of load, .8; frequency, 7200 alternations per minute.—Find the line loss and drop.

Remembering that the power factor is that fraction by which the apparent power or volt-amperes must be multiplied to give the true power, the apparent power to be delivered is $\frac{250 \text{ KW}}{.8} = 312.5$ apparent KW The current, therefore, at 2000 volts will be $\frac{312500}{2000} = 156.25$ amperes. From the table of reactances under the heading "18 inches," and corresponding to No. 0 wire, is obtained the constant .228. Bearing the instructions of the sheet in mind, the reactance-volts of this line are, 156.25 (amperes) × 10 (thousands of feet) × .228=356.3 volts, which are 17.8 per cent. of the 2000 volts to be delivered.

From the column headed "Resistance-Volts" and corresponding to No. 0 wire is obtained the constant .197. The resistance-volts of the line are, therefore, 156.25 (amperes) × 10 (thousands of feet) × .197 =307.8 volts, which are 15.4 per cent. of the 2000 volts to be delivered.

Starting, in accordance with the instructions of the sheet, from the point where the vertical line, which at the bottom of the sheet is marked "Load Power Factor" .8, intersects the inner or smallest circle, lay off horizontally and to the right the resistance-E. M. F. in per cent. (15.4) and "*from the point thus obtained*" lay off vertically the reactance-E. M. F. in per cent. (17.8). The last point falls at about 23 per cent., as given by the circular arcs. This, then, is the drop in per cent. of *the E. M. F. delivered.* The drop in per cent. of the *generator* E. M. F. is, of course, $\frac{23}{100+23} = 18.7$ per cent.

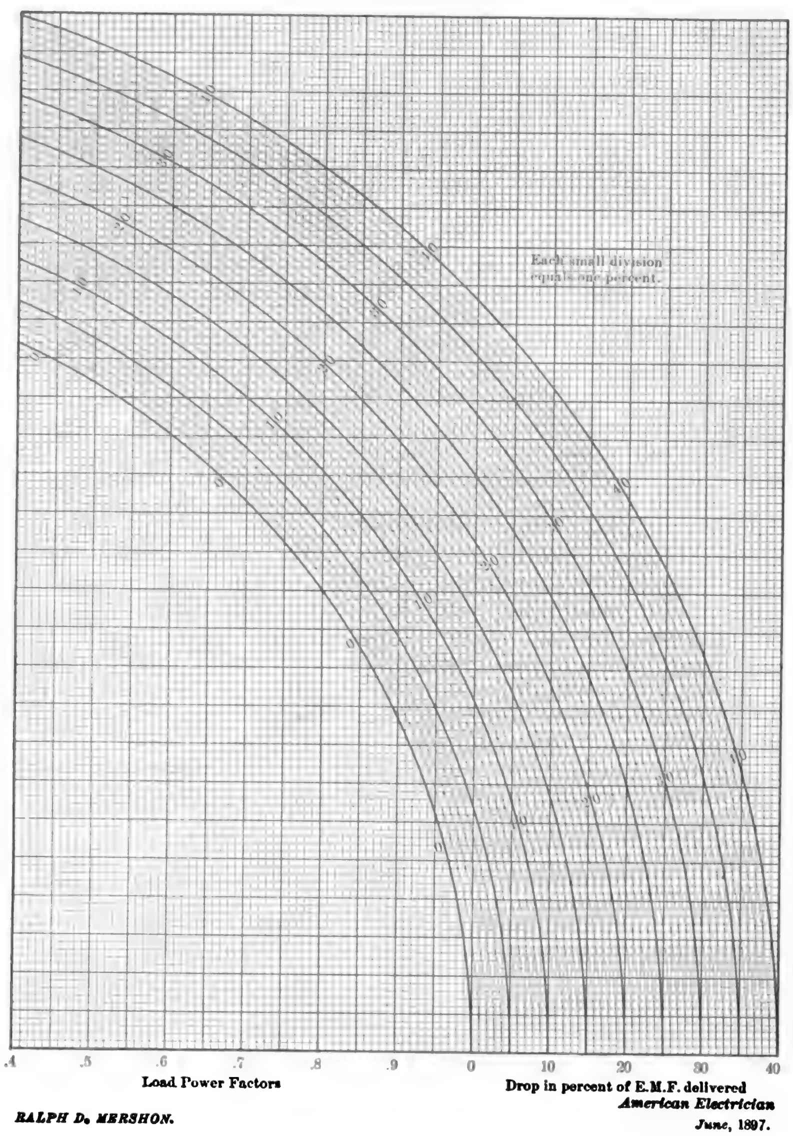
The percentage *loss of power* in the line has not, as with direct current, the same value as the percentage drop. This is due to the fact that the line has reactance and also that the apparent power delivered to the load is not identical with the true power—that is, the load power factor is less than unity. The loss must be obtained by calculating C^2R for the line, or, what amounts to the same thing, by multiplying the resistance volts by the current.

The resistance volts in this case are 307.8 and the current 156.25 amperes. The loss is 307.8 × 156.25 = 48.1 KW. The percentage *loss* is $\frac{48.1}{250 + 48.1} = 16.1$ per cent. Therefore, for the problem taken the *drop* is

TABLE AND CHART FOR OBTAINING THE DROP IN ALTERNATING-CURRENT LINES HAVING SELF-INDUCTANCE AND RESISTANCE.

By means of the Table calculate the *Resistance-Volts* and the *Reactance-Volts* in the line, and find what per cent. each is of the E.M.F. delivered at the end of the line. Starting from the point on the chart where the vertical line corresponding with power-factor of the load intersects the smallest circle, lay off in per cent. the resistance E.M.F. horizontally and to the right; from the point thus obtained lay off upward in per cent. the reactance-E.M.F. The circle on which the last point falls gives the drop in per cent. of the E.M.F. delivered at the end of the line. Every tenth circle arc is marked with the per cent. drop to which it corresponds.

Size of Wire B.&S.	Weight—Pounds per 1000 ft. Single Wire.	Resistance-Volts in 1000 ft. of Line (2000 ft. of wire) for One Ampere ($\sqrt{\text{Mean Square}}$).	Reactance-Volts in 1000 ft. of Line (=2000 ft. of Wire) for One Ampere ($\sqrt{\text{Mean Square}}$) at 7200 Alternations per Minute for the Distance Given Between Centers of Conductors.										
			½"	1"	2"	3"	6"	9"	12"	18"	24"	30"	36"
0000	639	.098	.046	.079	.111	.130	.161	.180	.193	.212	.225	.235	.244
000	507	.124	.052	.085	.116	.135	.167	.185	.199	.217	.230	.241	.249
00	402	.156	.057	.090	.121	.140	.172	.190	.204	.222	.236	.246	.254
0	319	.197	.063	.095	.127	.145	.177	.196	.209	.228	.241	.251	.259
1	258	.248	.068	.101	.132	.151	.183	.201	.214	.233	.246	.256	.265
2	201	.313	.074	.106	.138	.156	.188	.206	.220	.238	.252	.262	.270
3	159	.394	.079	.112	.143	.162	.193	.212	.225	.244	.257	.267	.275
4	126	.497	.085	.117	.149	.167	.199	.217	.230	.249	.262	.272	.281
5	100	.627	.090	.121	.154	.172	.204	.223	.236	.254	.268	.278	.286
6	79	.791	.095	.127	.158	.178	.209	.228	.241	.260	.272	.283	.291
7	63	.997	.101	.132	.164	.183	214	.233	.246	.265	.278	.288	.296
8	50	1.260	.106	.138	169	.188	.220	.238	.252	.270	.284	.293	.302



18.7 per cent. and the *loss* is 16.1 per cent. If the problem be to find the size wire for a given drop, it must be solved by trial. Assume a size of wire and calculate the drop; the result in connection with the table will show the direction and extent of the change necessary in the size of wire to give the required drop.

The effect of line reactance in increasing the drop should be noted. If there were no reactance the drop in the above example would be given by the point obtained in laying off on the chart the resistance-E. M. F. (15.4) only. This point falls at 12.4 per cent. and the drop in terms of the generator E. M. F. would be $\frac{12.4}{112.4} = 11$ per cent., instead of 18.7 per cent. Anything therefore which will reduce reactance is desirable.

Reactance can be reduced in two ways. One of these is to diminish the distance between wires. The extent to which this can be carried is limited in the case of a pole line to the least distance at which the wires are safe from swinging together in the middle of the span; in inside wiring by the danger from fire. The other way of reducing reactance is to split the copper up into a greater number of circuits and arrange these circuits so that there is no inductive interaction. For instance, suppose that in the example worked out above, two No. 3 wires were used instead of one No. 0 wire. The resistance-volts would be practically the same, but the reactance-volts would be less in the ratio $\frac{1}{2} \times \frac{.244}{.228} = .535$, since each circuit would bear half the current the No. 0 circuit does, and the constant for No. 3 wire is .244 instead of .228—that for No. 0. The effect of subdividing the copper is also shown if in the example given it is desired to reduce the drop to, say, one-half. Increasing the copper from No. 0 to No. 0000 will not produce the required result for, although the resistance-volts will be reduced one-half, the reactance-volts will be reduced only in the ratio $\frac{.212}{.228}$. If, however, *two* inductively independent circuits of No. 0 wire be used, the resistance- and reactance volts will both be reduced one-half and the drop will therefore be diminished the required amount.

The component of drop due to reactance is best diminished by subdividing the copper or by bringing the conductors closer together, and is little affected by change in size of conductors.

An idea of the manner in which changes of power factor affect drop is best gotten by an example. Assume distance of transmission, distance between conductors, E. M. F. and frequency, the same as in the previous example. Assume the *apparent* power delivered the same as before, and let it be constant, but let the power factor be given several different values; the true power will, therefore, be a variable depending upon the value of the power factor. Let the size of wire be No. 0000. As the apparent power, and hence the current, is the same as before, and the line resistance is one-half, the resistance-E. M. F. will in this case be $\frac{15.4}{2}$, or 7.7 per cent. of the E. M. F. delivered. Also, the reactance-E. M. F. will be $\frac{.212}{.228} \times 17.8 = 16.5$ per cent. Combining these on the chart for a power factor of .4, and deducing the drop in per cent. of the generator E. M. F., the value obtained is 15.3 per cent.; with a power factor of .8 the drop is 14 per cent.; with a power factor of unity it is 8 per cent. If in this example the *true* power, instead of the *apparent* power, had been taken as constant, it is evident that the values of drop would have differed more widely, since the current, and hence the resistance- and reactance-volts, would have increased as the power factor diminished. The condition taken more nearly represents that of practice.

If the line had resistance and no reactance, the several values of drop, instead of 15.3, 14 and 8, would be 3.2, 5.7 and 7.2 per cent., respectively, showing that for a load of lamps the drop will not be much increased by reactance, but that with a load, such as induction motors, whose power factor is less than unity, care should be taken to keep the reactance as low as practicable. In all cases it is advisable to place conductors as close together as good practice will permit.

When there is a transformer in circuit and it is desired to obtain the combined drop of transformer and line, it is necessary to know the resistance- and reactance-volts of the transformer. The resistance-volts of the combination of line and transformer are the sum of the resistance-volts of the line and the resistance-volts of the transformer. Similarly the reactance-volts of the line and transformer are the sum of their respective reactance-volts. The reactance and resistance-E. M. F.s of transformers may usually be obtained from the makers and are ordinarily given in per cent.* These percentages express the values of the reactance- and resistance-E. M. F.s when the transformer delivers its normal *full-load* current and they express these values in terms of the normal *no-load* E. M. F. of the transformer.

Consider a transformer built for transformation between 1000 and 100 volts. Suppose the resistance and reactance-E. M. F.s given are 2 per cent. and 7 per cent. respectively. Then the corresponding voltages when the transformer delivers full-load current are 2 and 7 volts or 20 and 70 volts according as the line whose drop is required is connected to the low-voltage or high-voltage terminals. These values, 2—7 and 20—70, hold no matter at what voltage the transformer is operated, since they depend only upon the strength of current, providing it is of the normal frequency. If any other than the full-load current is drawn from the transformer the reactance- and resistance-volts will be such a proportion of the values given above as the current flowing is of the full-load current. It may be noted in passing that when the resistance- and reactance-volts of a transformer are known, its regulation may be determined by making use of the chart in the same way as for a line having resistance and reactance.

As an illustration of the method of calculating the drop in a line and transformer, and also of the use of table and chart in calculating low-voltage mains, the following example is given:

Problem: A single-phase induction motor is to be supplied with 20 amperes at 200 volts; alternations, 7200 per minute; power factor, .78. The distance from transformer to motor is 150 feet and the line is No. 5 wire 6 inches between centers of conductors. The transformer reduces in the ratio $\frac{2000}{200}$, has a capacity of 25 amperes at 200 volts, and when delivering this current and voltage its resistance- E. M. F. is 2.5 per cent., its reactance- E. M. F. 5 per cent. Find the drop.

The reactance of 1,000 feet of circuit consisting of two No. 5 wires, 6 inches apart, is .204. The reactance-volts therefore are $.204 \times \frac{150}{1000} \times 20 = .61$ volts.

The resistance-volts are

$$.627 \times \frac{150}{1000} \times 20 = 1.88 \text{ volts.}$$

At 25 amperes the resistance-volts of the transformer are 2.5 per cent. of 200, or 5 volts. At 20 amperes they are $\frac{20}{25}$ of this, or 4 volts. Similarly, the transformer reactance-volts at 25 amperes are 10 and at 20 amperes are 8 volts. The combined reactance-volts of transformer and line are 8 + .61 = 8.61, which is 4.3 per cent. of the 200 volts to be delivered. The combined resistance-volts are 1.88 + 4, or 5.88, which is 2.94 per cent. of the E. M. F. to be delivered. Combining these quantities on the chart with a power factor of .78, the drop is 5 per cent. of the delivered E. M. F. or $\frac{5}{105} = 4.8$ per cent. of the impressed E. M. F. The transformer must be supplied with $\frac{2000}{.952} = 2100$ volts, in order that 200 volts shall be delivered to the motor.

The table is made out for 7200 alterna-

*When the required values cannot be obtained from the makers they may be measured. Measure the resistance of both coils. If the line to be calculated is attached to the high-voltage terminals of the transformer, the equivalent resistance is that of the high-voltage coil plus the resistance obtained by *increasing* in the square of the ratio of transformation the measured resistance of the low-voltage coil. That is, if the ratio of transformation is 10, the equivalent resistance referred to the high-voltage circuit is the resistance of the high-voltage coil, plus 100 times that of the low-voltage coil. This equivalent resistance multiplied by the high-voltage current gives the transformer resistance-volts referred to the high-voltage circuit. Similarly, the equivalent resistance referred to the low-voltage circuit is the resistance of the low-voltage coil, plus that of the high-voltage coil *reduced* in the square of the ratio of transformation. It follows, of course, from this that the values of the resistance-volts referred to the two circuits bear to each other the ratio of transformation. To obtain the reactance-volts, short-circuit one coil of the transformer and measure the voltage necessary to force through the other coil its normal current at normal frequency. The result is, nearly enough, the reactance-volts. It makes no difference which coil is short-circuited, as the results obtained in one case will bear to those in the other the ratio of transformation. If a close value is desired, subtract from the square of the voltage reading the square of the *resistance*-volts, and take the square root of the difference as the reactance-volts.

tions, but will answer for any other number if the values for reactance be changed in the direct proportion to the change in alternations. For instance, for 16,000 alternations multiply the reactances given by $\frac{16000}{7200}$. For other distances between centers of conductors interpolate the values given in the table. As the reactance values for different sizes of wire change by a constant amount, the table can, if desired, be readily extended for larger or smaller conductors.

The table is based on the assumption of sine currents and E. M. F.s. The best practice of to-day produces machines which so closely approximate this condition that results obtained by the above methods are well within the limits of practical requirements.

Polyphase Circuits.—So far single-phase circuits only have been dealt with. A simple extension of the methods given above adapts them to the calculation of polyphase circuits. A four-wire *quarter-phase* (two-phase) transmission may, so far as loss and regulation are concerned, be replaced by two single-phase circuits identical (as to size of wire, distance between wires, current and E. M. F.) with the two circuits of the quarter-phase transmission, provided that in both cases there is no inductive interaction between circuits. Therefore, to calculate a four-wire, quarter-phase transmission, compute the single-phase circuit required to transmit one-half the power at the same voltage. The quarter-phase transmission will require two such circuits.

A three-wire, *three-phase* transmission, of which the conductors are symmetrically related, may, so far as loss and regulation are concerned, be replaced by two single-phase circuits having no inductive interaction, and identical with the three-phase line as to size, wire and distance between wires. Therefore, to calculate a three-phase transmission, calculate a single-phase circuit to carry one-half the load at the same voltage. The three-phase transmission will require three wires of the size and distance between centers as obtained for the single-phase.

A three-wire, quarter-phase transmission may be calculated *exactly*, as regards loss, and *approximately* as regards drop, in the same way as for three-phase. It is possible to exactly calculate the drop, but this involves a more complicated method than the approximate one. The error by this approximate method is generally small. It is possible also to get a somewhat less drop and loss with the same copper by proportioning the cross section of the middle and outside wires of a three-wire, quarter-phase circuit to the currents they carry, instead of using three wires of the same size. The advantage of the course is not great and it will not be considered here.

The above statements as to calculation of polyphase circuits are made subject to certain conditions in arrangement of conductors. These conditions will be considered.

Arrangement of Conductors.—The two circuits of a quarter-phase transmission should be so arranged that there is no in-

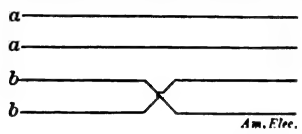


FIG. 2.—ARRANGEMENT OF CONDUCTORS.

ductive interaction. Such arrangement may be accomplished in either of the ways shown in Figs. 2 and 3. Fig. 3 shows the two wires, *a a*, of one circuit and the two, *b b*, of the other circuit, at opposite ends of the diagonals of a square. With such an arrangement there is no inductive action between the two circuits, since none of the lines of induction due to the one can be linked through the other. Fig. 2 shows the two circuits side by side (they may be in any other relative position providing it is preserved throughout) and the wires of the circuit, *b b*, interchanged at their middle point. Such an arrangement fulfills the requirements, since all the linkages from *a a* to *b b*, and from *b b* to *a a*, in one-half the transmission are exactly offset by the same number of opposite linkages in the other half of the transmission.

The three wires of a three-phase transmission should be so arranged that they are symmetrically related. Figs. 4 and 6 show two methods of accomplishing this. In Fig. 4 the three wires are at the three corners of an equilateral triangle. In Fig.

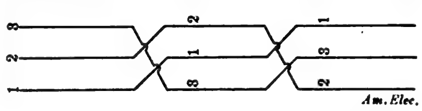
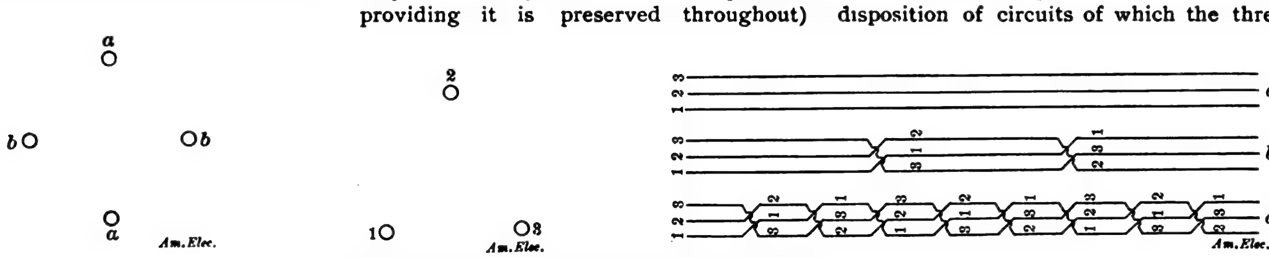


FIG. 6.—ARRANGEMENT OF CONDUCTORS.

6 the wires are all on the same cross arm, and are twice interchanged, once at one-third and once at two-thirds of the transmission distance. In Fig. 4, since the wires bear equal currents, of symmetrical phase relation, and because of the symmetry of arrangement, the inductive action between any one wire and the remaining two is the same, no matter which wire be considered. In Fig. 6 the same is true, as may be seen by tracing the wires throughout their length. The arrangement of Fig. 6 answers for the case of all the power transmitted to the *end* of the line, and under such conditions only the two transpositions shown are necessary. If power is tapped off at intermediate points and perfect equalization is desired, the wires should be interchanged as shown in Fig. 6, between all points at which there is connection made to the line—that is, there should be two transpositions between the power station and the first receiving station, two between the first and second receiving stations, and so on.

In some cases where the triangular arrangement of conductors is employed, the wires are in addition interchanged. This is unnecessary unless it is not possible to arrange the wires in a triangle which is practically equilateral, or unless there are two or more circuits adjacent and it is desired to have them inductively independent. When the latter is the case, the circuits should be disposed as in Fig. 5, which represents a top view of the triangular arrangement. The first circuit, *a*, runs straight through; the second, *b*, is interchanged twice; the third, *c*, is interchanged eight times; the fourth would be interchanged twenty-six times, etc. If it is necessary to interchange the first circuit because of inequality in the sides of the triangle, *b* must be taken as the first circuit, *c* the second, etc. *b* and *c* of Fig. 5 also answer for the disposition of circuits of which the three



FIGS 3, 4 AND 5.—ARRANGEMENT OF CONDUCTORS.

wires are on the same cross arm as in Fig. 6; then *b* is the first circuit, *c* the second, etc.

In a quarter-phase three-wire circuit there is little advantage, if any, in arrangement other than that of wires equidistant and side by side without interchange. The two circuits of the three-wire, quarter-phase transmission cannot be made inductively independent, and the complication already mentioned in accurately calculating the drop is due to this fact.

If some such arrangement as those given is not employed—that is, if the four wires of the quarter-phase or the three of the three-phase are strung straight through on the same cross arms—the unbalanced inductive action will be the cause of an unbalancing of the system, which in a short transmission may not amount to much, but which in a long transmission may cause considerable annoyance.

The rule given some time back for calculating a three-phase line applies closely but not exactly to Fig. 6. Fig. 6 cannot be exactly replaced by two single-phase circuits, the wires of which are the same distance apart as the adjacent wires of Fig. 6. No two wires of Fig. 6 are the same distance apart throughout their length. They are one distance apart for two-thirds their length and twice that distance for the remaining third. The equivalent single-

phase circuits must, therefore, have between wires a distance intermediate between that of adjacent and extreme wires of Fig. 6. Consider a three-phase line of which adjacent wires are 18 inches apart. The equivalent single-phase circuits must have their wires apart a distance intermediate between 18 inches and 36 inches. What this distance is can be determined by the table of reactances. Suppose the wire be No. 0. The constant for 18 inches is .228; that for 36 inches is .259. Therefore the constant of the equivalent single-phase circuit is $\frac{.228 + .228 + .259}{3} = .238$, which corresponds to a distance of about 22 inches.

This shows one advantage which the triangular arrangement has over that of Fig. 6; for the same distance between adjacent conductors the reactance with the triangular arrangement is less than with that of Fig. 6. If close results are wanted with an arrangement like Fig. 6 the average constant for any two wires must be taken in calculating the reactance volts.

Compensation for Drop.—However the drop in feeders is compensated for, whether by "boosters" or by the use of choke coils or resistances, it is necessary, in order to secure good regulation, that there be employed some means of indicating at all times the voltage delivered at the receiving end of the transmission. One of the oldest devices for this purpose is that of using "pressure wires" or leads run from the end of the feeder back to the generating station, where they are attached to a voltmeter. This method was first employed in direct-current work. It answers equally well for alternating currents, providing the two pressure wires are the same distance from any other wires bearing alternating current, or are frequently interchanged so that no inductive effect is upon them.

Pressure wires are objectionable, however, on the score of cost, especially in the case of numerous and long feeders. Other contrivances, designed to do away with pressure wires, have been used. They depend for their action on the direct or indirect measurement of the current flowing in the feeders, and are supposed to give an indication directly proportional to this current. Although they answer well enough when used on feeders carrying a lamp load only, they are useless on feeders carrying a load of motors or lamps and motors. The reason for this is that with the same current flowing the drop in a line may vary considerably because of variations in the power factor of the load. This is clearly shown in one of the problems taken up under calculation of drop. The power factor of a load made up wholly or in part of induction motors will from time to time vary quite widely. This is especially true of a circuit carrying a day load of motors and a night load of lamps.

So far as is known to the writer, there has never been published a device which will, without regard to the nature of the load, indicate the voltage at the receiving end of an alternating current line; which will, in other words, take account of current, power factor, reactance and resistance. Such a device is, however, possible. Suppose that at the station there were produced three E. M. F.s, proportional to and in step with, respectively, the E. M. F. impressed upon the line at the station, the reactance E. M. F. and the resistance-E. M. F., and that these three were combined in the same way as are their counterparts in the line. Their resultant would be proportional to and in step with the E. M. F. at the far end of the line, and a voltmeter actuated by this resultant would at all times give an indication proportional to the E. M. F. of the load.

Figs. 7 and 8 show methods of connection which fulfill the required conditions. Many variations from these connec-

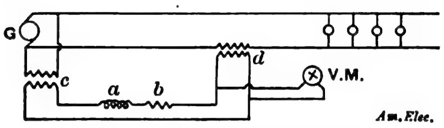


FIG. 7.—VOLTMETER CIRCUIT.

tions are possible, but they all involve the same principle. In Fig. 7 *d* is a converter in series with the main line and yielding in its secondary circuit a current always proportional to and in step with the line current. *c* is a converter connected across the generator terminals and supplying in its secondary circuit an E. M. F. in step with and proportional to that of the generator. *a* is an inductive resistance or reactance coil and *b* an ohmic resistance, both so adjusted with respect to the current from converter *d* that for a given current through them their respective E. M. F.s have the same value relative to the E. M. F. of converter *c*, as the reactance- and resistance-

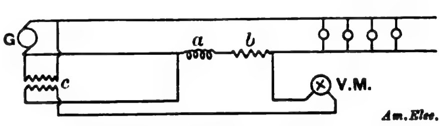


FIG. 8.—VOLTMETER CIRCUIT.

E. M. F.s of the line have to the E. M. F. of the generator. The current supplied by converter *d* being in step with and proportional to the main current, the reactance-E. M. F, of *a* and the resistance E. M. F. of *b* will be proportional to and in step with the corresponding quantities of the line and with the connections shown in the figure, they will reduce or cut down the E. M. F. of *c* in the same proportion as their line counterparts do the generator E. M. F. The voltmeter will therefore always give an indication proportional to the voltage delivered at the end of the line. Fig. 8 accomplishes the same result without passing any current through converter *c* except that necessary for the voltmeter. This method of indicating the load voltage has proven itself perfectly satisfactory.

American Institute of Electrical Engineers.

The annual meeting of the American Institute of Electrical Engineers at Eliot, Me., will have the added attractions of furnishing to members an opportunity for an outing in a beautiful locality, and also, through the Greenacre Conferences held at the same place, enabling them to obtain a glimpse of a typical New England intellectual movement.

OXIDATION OF CARBON WITHOUT HEAT.

BY WILLARD E. CASE.

In an article by C. J. Reed, entitled "Thermo-Electric Batteries," in the AMERICAN ELECTRICIAN of April, 1897, are the following statements, which I desire to correct:

1. He says "that notwithstanding the very many alleged processes recently discovered for obtaining 'electricity from carbon without heat,' the fact remains that carbon has never yet been oxidized without the continuous application of external heat or of electrical energy, except at or above its igniting temperature."

In the early part of 1888 I did, in the course of experiments, oxidize carbon without heat. I then discovered that peroxide of chlorine acted upon gas carbon, giving an E. M. F. of .5 of a volt; upon sugar carbon, giving .3 of a volt, and upon powdered carbon, giving 1.24 volts. The carbons were analyzed and proven to be chemically pure. A careful analysis also showed that the carbons were completely oxidized, no intermediate compounds being formed. The cell was operated and the E. M. F. was observed and measured at normal temperatures. These analyses and measurements were all made in the most exact manner at the chemical laboratory of Cornell University.

2. He further states that "no researches capable of verification have yet been published which give an indication or proof that carbon has ever been oxidized at low temperature, except as above stated, viz.: the slow oxidization of amorphous carbon by an electric current when it is used as an anode in the electrolysis of an aqueous electrolyte, and the slow conversion of graphite into graphitic acid by repeatedly heating it with powerful oxidizing agents."

The experiments above referred to as made by myself were repeated and their results noted many times. They may all be verified at pleasure at the chemical laboratory at Cornell University or elsewhere. And further, both the experiments and the research which preceded them were incorporated in a paper by myself entitled "Electrical Energy from Carbon without Heat," and read before the American Institute of Electrical Engineers at a special meeting thereof in March, 1888. The paper was printed as a part of the proceedings of such Institute. The cell with which I performed the experiments was exhibited at the above-mentioned special meeting and there operated at normal temperature.

So, contrary to Mr. Reed's statements, it appears that carbon has been oxidized below its igniting temperature without the continuous application of external heat or of electrical energy, and that researches capable of verification have been published indicating or proving that carbon has been oxidized at low temperatures in other than the two ways mentioned in Mr. Reed's article.

Oxidation of carbon also takes place at normal temperatures when it is in combination with other substances. In this manner it is constantly going on about us on every side in the gradual decay of wood, which is a natural fuel. There are numer-

ous other cases which could be cited ; we have an example in the human body of a most efficient machine: its carbon compounds are oxidized at normal temperature and carbonic acid gas, the product of that oxidation, is exhaled at every breath.

THERMO-ELECTRIC BATTERIES.

BY PROF. WM. A. ANTHONY.

Mr. Reed in his article in your issue for April classes the Jacques cell and other similar battery cells as thermo-electric elements. If this be so, then, according to his own showing, heat must be converted directly into electric energy. And again, for this to be the case, there must be in the apparatus a high and a low temperature—a source of heat and a refrigerator. There is no evidence that such is the case in the Jacques cell, and I venture to predict that a current would be developed the same as in the experiments recorded, if the cell and entire apparatus were in an enclosure where the temperature was maintained at the degree required for the chemical action.

In other words, the operation of the cell does not require the continuous application of heat, but only that the cell be placed where the temperature is sufficiently high. As well say that a Daniels cell is a thermo-electric cell in the polar regions, where normally it would be frozen solid, because artificial heat would there be required to maintain it in a condition to operate. I maintain that it is temperature, and not heat, that is required to maintain the Jacques and similar cells in action. If Mr. Reed is to maintain his position he must show that a difference of temperature is requisite, and that heat disappears when the circuit is closed; or that, other things remaining the same, the temperature rises when the circuit is open.

The "tin-chromic-chloride" cell is in its action at the high temperature, just as much a galvanic battery as any zinc-copper battery, and if we happen to be living at that temperature we could maintain the cell in action by renewing the materials as they were consumed, exactly as we now renew the materials of a gravity cell. True, if we complete the cycle and restore the materials in the cell to their original condition, any energy that the cell may have developed during the cycle must have been derived from without. But so it is with the gravity cell. We may take the zinc sulphate and reduce it to metallic zinc and say that the energy developed by the cell is derived from the heat energy required to reduce the zinc, but no one would for that reason call a gravity cell a thermo-electric element.

In a thermo-electric element heat energy is, as Mr. Reed says, directly converted into electric energy. This is not the case in the cells where carbon is the material consumed.

Electricity for the Brooklyn Elevated.

Though official announcement has not yet been made, it is understood that it has been definitely decided to equip the Brooklyn elevated railways with electricity. Owing to the flexibility of the Sprague system, whereby a single car or large train can be equally well operated, its adoption is favored on the Brooklyn roads.

220-VOLT LAMPS.

BY ALFRED H. GIBBINGS, A. I. E. E.,

Electrical Engineer to the Corporation of Bradford, England.

Having been invited by the editor of the AMERICAN ELECTRICIAN to give to American electrical readers the benefit of my experience in high-voltage, electric incandescent lighting, I do not hesitate to say that the 220-volt lamp has come to stay. By 220 volts I refer, of course, to all voltages between 200 and 230. In considering the lamp I shall, of course, also consider the reasons for and benefits accruing from its adoption. Two or three years ago the matter was not in such an advanced stage, nor was professional opinion nearly so unanimous in its favor as it is to-day. But electrical science grows apace, and many another important development has been born and matured in less time than it has taken to raise the standard of electricity supply in Great Britain from 110 volts to 220 volts.

Three years ago many systems of supply for small townships were designed for continuous current at 100–115 volts on the three-wire system. To-day that pressure is obsolete for any new schemes, while those which already exist are rapidly being "changed over," and even the alternating systems are being changed as far as the pressure of distribution on the low-tension network is concerned.

As examples of these changes, I mention the following towns which have already declared for 200–230 volts for all future applications for current, and separately enumerating those which have alternating and those which have continuous systems of supply.

1. Towns having alternating-current systems, and which have adopted 200–230 volts as the supply pressure:

Cheltenham, Edinburgh, Holloway, Southport, Wandsworth, Croydon, Blackpool, Taunton, Tunbridge Wells, Islington, Cardiff, Kingston-on-Thames, Bolton, Wallasey, &c.

2. Towns having continuous-current systems, and which have adopted 200–230 volts as the supply pressure:

Aberdeen, Burnley, Brighton, Bradford, Birkenhead, Belfast, Chester, Dewsbury, Dundee, Glasgow, Guildford, Hone, Hull, Kensington and Knightsbridge, Llandrindod, Wells, Manchester, Nottingham, Notting Hill, Oldham, Oswestry, Preston, Richmond, Shrewsbury, Southampton, St. James and Pall Mall, St. Pancras vestry, Westminster, Liverpool, York, etc.

It will thus be seen that the 220-volt lamp (which we can assume to be the representative voltage for the sake of brevity) has already obtained a considerable foothold in Great Britain. Of the above-named towns Bradford, with a population of 450,000, was the first to supply the whole of its electricity consumers at the higher pressure. It was also the first system of public electricity supply which was owned and operated by a municipality, the works being opened in 1889, and the supply having been absolutely continuous ever since.

When I had the honor of being appointed in November, 1895, to the management of this interesting electricity works there were about 50 consumers using 230-volt lamps. I then determined to enter upon a wholesale change of pressure, and the work entailed and experience gained in this matter will be better understood from the following figures, which represent the business of the department at 230 volts in December, 1896:

Number of consumers	530
Number of incandescent lamps:	
8 CP	2,492
16 CP	11,795
25 CP	169
32 CP	1,298
50 CP	167
100 CP	120
150 CP	8
200 CP	32
250 CP	5
300 CP	14
Total equivalent in 8 CP	35,895
Number of arc lamps:	
Public arc lamps (15 amperes) 4 in series.	8
Private arc lamps (10 amperes), 4 in series (single carbon)	359
Private arc lamps (5 amperes), 2 in series (Jandus and other inclosed type arcs).	18
Private arc lamps (5 amperes), 2 in series (double carbon)	48
Number of motors of equivalent 160 HP	71

The equivalent of the whole of the above in 8-CP lamps at 3.5 watts per candle is 49,653, which has since been increased (to May 1, 1897) to an equivalent of over 60,000 8-CP lamps, connected and supplied in various forms at 230 volts.

Having pointed out in a very brief and general manner what is being done in England with the 220-volt lamp, I will now endeavor to give, in the first place, some of the experiences actually gained during the last four years with the daily use of this voltage and in changing over from the

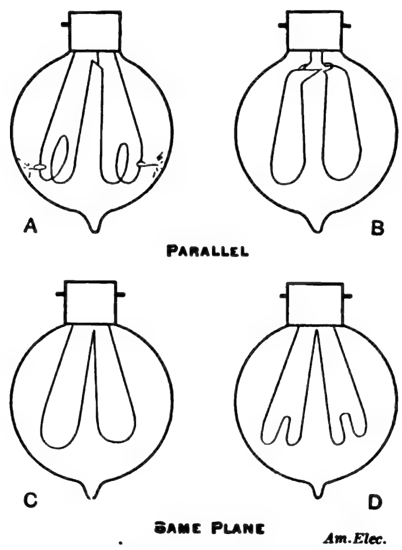


FIG. 1.—DOUBLE-FILAMENT 220-VOLT LAMPS.

110 to the 220 volts on old installations; and second, some of the reasons for adopting the 220 volt-lamp.

Incandescent Lamps.—Without going into the entire history of the development of the 220-volt lamp, I may say at once that many manufacturers are now making them quite as efficient and satisfactory as those for 110 volts. Indeed, it would be difficult to detect by mere inspection in what the

difference consists. They are made in a similar size of bulb, have similar terminals, may be obtained for all ranges of candle power, and are equal in life and reliability. If there is any perceptible difference it is in the form of the filament. Of course, each maker has his own peculiar type of filament, but as a matter of fact they may be divided into two great classes—double-filament and single-filament lamps. In the double-filament, high-voltage lamp the filaments are arranged either in the same plane with each other or are parallel to one another, and these are illustrated diagrammatically in Fig. 7.

It will be readily seen from the four examples in this figure that a very much greater space in the globe is occupied by the double filaments than is usually required for 100-volt lamps. The inevitable result of this arrangement is that the filaments have an increased tendency either to short-circuit upon themselves or to touch the glass. This liability becomes rather a serious contingency if the lamp is used in any position out of the vertical, *i. e.*, if used with the bulb at any angle between 0° and 90° with the horizontal. When used with the bulb in a perfectly vertical position, collar upward, these lamps are very satisfactory.

The filaments in the type marked A are shown shackled to the glass. This is not a good arrangement, as there is a liability to air leakage at the point of junction of the shackle with the glass through frequent expansion and contraction, and the filament itself is also liable to be cut by the shackle. With regard to double-filament lamps, therefore, it is better to choose the lesser of the two evils and rely upon

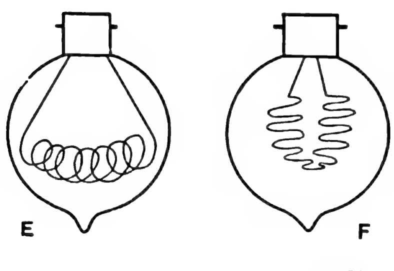


FIG. 2.—SINGLE-FILAMENT 220-VOLT LAMPS.

the unshackled and self-supporting filament. We now come to single-filament lamps. This type is, of course, more nearly like those in general use for lamps of 100–115 volts. The filament, however, must either be twice the usual length or of less sectional area. In either case the filament is much longer than that required for 100–115 volt lamps, and hence some device in the nature of convolutions or "waves" must be used in order that the filament shall not occupy too great a space within the globe.

In Fig. 2 illustrations are given of two forms of single-filament lamps. A casual glance will be sufficient to observe that the type marked F occupies less space than that marked E, and it is this feature which makes it perfectly adapted for use in any position. This type is made by the Zürich Incandescent Lamp Company, and is the most efficient and satisfactory high-voltage lamp of which I know. Out of a general consignment of lamps made and supplied by this firm for myself, I took six on Apr. 21, 1896, for the purpose of testing. These were kept continuously burning from that day until Dec. 30 of the same year, having been on circuit for 6072 hours. As they are still each intact it is impossible to say what their "life" may be.

There is now no difficulty in obtaining a supply of 220-volt lamps. In fact, one cannot now take up an English electrical journal without finding in the advertisement of all the leading lamp makers the statement: "High-Voltage Lamps a Specialty." Expensive machinery is being made by many firms on the Continent for the manufacture of these lamps. There will always be uses for 110-volt lamps, but the central-station engineer who does not take the present opportunity of increasing the voltage of supply will find himself very shortly sadly behind the times and with a problem on his hands.

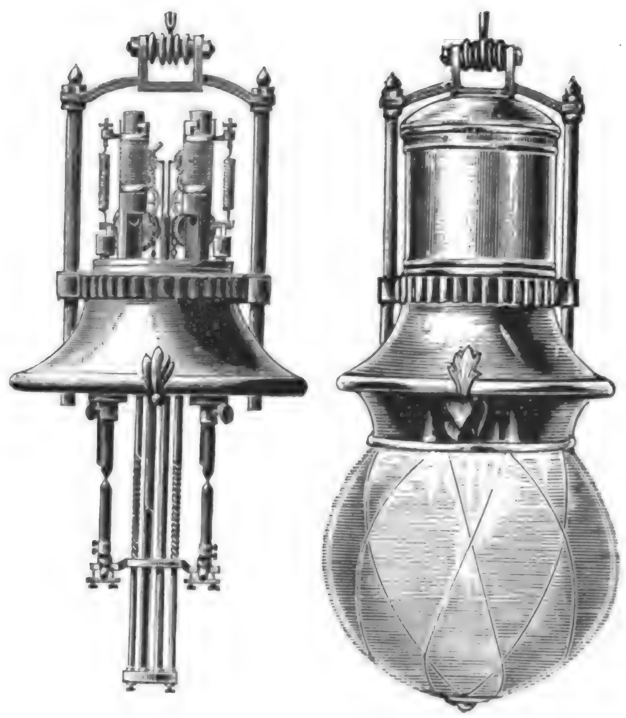


FIG. 3.—ARC LAMP WITH TWO INDEPENDENT PAIRS OF CARBONS.

Wiring, Fittings and Installation Work.—I have very little to say respecting the present forms and classes of wiring and fittings when used for a pressure of 220 volts. It may be taken for granted that ordinary good-class installation work for 110 volts will be found equally satisfactory for 220 volts. This is with me a matter of personal experience resulting from changing the pressure of over 500 installations. Out of these about a dozen had to be rewired, but the supplanted wiring of these installations consisted of merely *cotton-covered wire!*

Provided, therefore, that ordinary good vulcanized rubber-covered wire is used, no trouble whatever will be experienced.

With regard to fittings the case is slightly different. Bases of good porcelain, slate, or vulcanite, etc., are quite good enough as they exist at present for 110 volts, and the insulation is ample. The chief alteration required for 220-volt work consists in greater breaking distance between the contacts of switches used for controlling one or two lights. This distance or "spark-gap" should not be less than three-eighths of an inch. Fuse fittings also will require to have the length of fuse increased to at least 1-inch gap for the smallest sizes, and for perfect security it is advisable to adopt a design which has a bridge of insulating material between the terminals, thus necessitating the fuse wire being carried in the form of a crescent or **U**.

With regard to arc lamps and electric motors, the changes necessary to the higher voltage are immediately apparent to every electrician. Motors are equally satisfactory and equally efficient when wound for 220 volts as on 110-volt circuits. Arc lamps can either be run four in series if of the ordinary single-carbon type, and two in series if of the enclosed-arc type, or the double-carbon type designed by myself and illustrated herewith. This lamp consists of two independent sets of carbons connected in series on one base and contained in one globe.

The above lamp is arranged to burn with 5 amperes and two arcs at 220 volts, in place of 10 amperes and one arc at 110 volts. The efficiency is the same in each case. For further particulars and details concerning the changing of installations from 110 to 220 volts, the reader is referred to a paper of mine which I read before the Northern Society of Electrical Engineers, Manchester, England, on Feb. 8, 1897, and entitled "Electricity Supply at 230 Volts."

Some Reasons for Adopting 220-Volt Lamps.—The chief reason for adopting the 220-volt lamp is that it is a sound business transaction outside the mere technical advantages which follow in its train. Its real significance lies in the fact that by doubling the pressure the current is halved. Halving the current per lamp allows twice the number of lamps to be connected to any cable at the same current density. Hence the earning capacity of any cable when fully loaded is doubled; the cost of house-wiring is cheapened, due to the smaller sectional area of conductor required per lamp; and the loss in transmission is proportionately reduced for equal distances of the two pressures.

The voltage, however, being double that of 110 volts, there is another and almost greater advantage than those which I have just mentioned. I refer to the fact that the same current may be transmitted twice the distance with the same percentage fall of potential.

For instance, if with the three-wire system at 110 volts on either side the distance of supply is limited to one mile in each di-

rection, it is clear that the *area* served will be four square miles; but with the same system at 220 volts on either side, the distance limit of supply is increased to two miles in each direction, which represents an *area* of sixteen square miles.

The minor advantages which I have referred to as being of a mere technical nature may be said to consist, first, in a much more even pressure being maintained on the street mains at the feeder ends, and secondly in the application of the higher voltage to a greater variety of purposes. As an example of the latter, I may mention the possibility of driving an electrical tramcar system from the same power station and from the same 'bus bars. Such developments are being rapidly pushed forward in this country, and in a few years hence, when we are contemplating the great extension and rapid headway of electric lighting and power in all parts of the world, we shall undoubtedly be able to look back and find this progress and popularity due in great measure to the universal adoption of the 220-volt lamp.

THE MOORE VACUUM LIGHT.

At an exhibition, May 27, by Mr. D. McFarlan Moore, of his vacuum light at the Moore laboratory, in Newark, N. J., the improvements introduced during the past year were detailed to an audience of seventy-five or more invited guests. In a preliminary address, Mr. E. J. Wessels, president of the Moore Company, stated that since Mr. Moore's last public demonstration he has made the following advances:

"First. He has solved the wiring problem. All the tubes are now run in multiple arc. Formerly each had a separate wire. Second. He has perfected his rotator, and it possesses great advantages over the original vibrators. Now one rotator and coil transform the current for all tubes. Formerly each tube used a vibrator and coils. Now only one-twenty-fifth as much apparatus is required. Third. The amount of power required to produce a given quantity of light has been reduced in about the same proportion. Fourth. The average rate of vibration has been increased from 6000 to 50,000 per minute."

The new form of vacuum break consists of a wheel mounted on the end of the armature shaft of a motor; both the circuit-breaking wheel and armature are contained in a vacuum tube, the field of the motor being exterior to the tube; the latter is 7½ ins. long and 2½ ins. in diameter. By means of the above described rotator, the number of breaks has been increased to 50,000 per minute; the vibrator formerly used only permitted 6000 breaks per minute to be made.

The room in which the exhibition was held was lighted by fourteen tubes, 7½ ft. long and 2½ ins. in diameter, located at the cornices and connected in parallel; the floor area of the space lighted was 250 sq. ft. The photograph reproduced herewith was taken by means of vacuum light, the exposure being thirty seconds.

The many beautiful effects produced by the vacuum light were much appreciated by the audience. As to efficiency, Mr. Moore claims that a gain of over 2000 per cent. has been made over the results obtained last year by a committee of the American Institute of Electrical Engineers, and that the calculations made by some members of the Institute at about that time showed the light, even then, to have a greater efficiency than the incandescent light.

GROUP PHOTOGRAPHED BY VACUUM LIGHT.

NOTES.

Financial Condition of the American Institute of Electrical Engineers.—The report of the secretary of the American Institute of Electrical Engineers for the year ending Apr. 30, 1897, shows a balance in the treasury of $1284.06, against which are chargeable outstanding bills of $465.55, leaving a net balance of $818.51. This showing is on its face more favorable than that at the end of the preceding year, the balance then being $239.99. On the other hand, the expenses for meetings and *Transactions* were about $900 less during the past than the preceding year. For some years the payments received for life-memberships ($100) had been spent for current expenses. The Council has provided that the amount of $2300 thus used shall be refunded and invested in a compounded membership fund, the sum of $500 per year to be set aside for this purpose.

The National Electric Light Convention.—The following are the papers to be read at the Niagara meeting of the National Electric Light Convention, to be held June 8, 9, and 10: "Standardizing Prices for Incandescent Light and Power," by Lieut. J. B. Cahoon; "Municipal Lighting," by W. Worth Bean; "Correct Method of Charging for Product," by C. L. Edgar; "The Niagara Transmission Line," by J. G. White; "Profitable Extensions of Electricity Supply Stations," by Arthur Wright (Brighton, England); "The Induction Factor: A New Basis of Dynamo Calculation and Classification," by Prof. Chas. A. Carus-Wilson; "Recent Progress in Arc Lighting," by Elihu Thomson; "The Daylight Work of Central Stations;" by T. C. Martin; "Niagara Power," by L. B. Stillwell; "Polyphase Motors," by B. F. Lamme; "Frequency Transformation," by Lieut. F. Jarvis Patten; "Rotaries for Transforming Alternating into Direct Current," by C. F. Scott. Among the topics to be discussed are the following: "Theft of Current and how to Deal with It;" "Commercial Results with Inclosed Arcs;" "Best Efficiency for Incandescent Lamps;" "Are the Large Arc Lighters Commercially Desirable?" "Lamp Carriers other than Ordinary Posts." Three important reports of committees will be made—on "Rules for Safe Wiring," "Standard Candle Power of Arc Lamps," and "Central Station Data." The paper by Mr. Stillwell will be read at the Park Pavilion on the evening of June 9, and will be illustrated by stereopticon views.

The Engineer's Year Book.—In the current volume of the Engineer's Year Book of the University of Minnesota, electrical engineering is well represented. In an article on the three-wire system, Mr. Truman Hubbard describes more than a half score of different modifications of the original Hopkinson-Edison system. Prof. Shepardson is represented by three articles—"A Novel Three-phase Alternator," "A Multifunctional Dynamo" and "A Convenient Ammeter Plugboard." The first named article describes the manner in which a Thomson-Houston arc machine was transformed into a three-phased alternator, and the second describes the devices by means of which an old-type Edison dynamo is made to answer as a generator of single, two and three-phased currents, and operate as a shunt, cumulative-compound or differentially-compound motor, or as a dynamo either singly or in multiple with a Mather machine over 400 ft. away, or with the same machine on the three-wire system. The third article shows a simple arrangement whereby a single ammeter is made to read with equal sensitiveness from 1 to 100 amperes.

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The Niagara Convention.

That the Niagara meeting of the National Electric Light Convention will be an unusually successful one there is every reason to believe. The location and the very general interest that has been manifested in the prospective meeting, assure a good attendance; while the papers to be read are in the aggregate much above the average of any previous convention. One or two, it is true, have the ear marks of the merely perfunctory composition, happily becoming rarer at each succeeding convention. On the other hand, the majority of the papers, judging from their titles and the names of the authors, are of first-class importance. Among the latter are those of Mr. Arthur Wright, Mr. C. L. Edgar and Lieut. J. B. Cahoon, which deal with the most important and timely subject now before the managers of central stations—a rational method of charging for electrical service. The convention is fortunate in having arranged to obtain the views of Mr. Wright on this subject, as he has made the most radical and successful innovations in that direction, a detailed account of which is given in the article by Mr. Bathurst in another column on the Brighton (England) station.

Of the committee reports, three will be of more than usual importance. That dealing with incandescent-lamp standardization will show that, in connection with the American Institute of Electrical Engineers, a satisfactory basis for standardization has finally been settled upon, the details of which have been worked up to the point of application. The report of central station data this time will not require to be accompanied by a disclaimer as to the accuracy of the figures presented, as these in part will represent the result of a personal investigation by an expert in the employ of the committee. Finally, the report of the committee on "Rules for Safe Wiring" will represent a task accomplished that at one time seemed impossible—a code of rules acceptable to both the insurance and electrical interests.

The Berliner Patent.

The full text of the opinion of the United States Supreme Court in the Berliner case, confirms the view expressed last month in these columns—that the entire question as to the validity of the Berliner patent remains open for future adjudication. Of the several grounds in the recent suit, the court passed upon the single one relating to unlawful and fraudulent delay in the Patent Office, its decision being that there was no evidence of fraud, and that the delay in the issue of the patent was not unlawful, the various steps that led to such delay having been legally taken; in other words, the delay is chargeable to the incompetency of the Patent Office officials in permitting advantage to be taken of the rules of the Office to delay the issue of the patent.

It has repeatedly been predicted that the allegation of fraud could not be supported, for the reason that there was little probability that the astute advisers of the American Bell Telephone Company would prejudice the patent by any procedure open to such a construction. From the beginning it was also seen that the Government was handicapped with respect to the claim that the patent is invalid on the score of invention. The suit just ended was therefore inadvisable from every point of view, and furnishes a fitting final chapter to a history of legal delays that will always make the Berliner case a *cause célèbre* in this special connection, as well as in others.

The real factors affecting the validity of the Berliner, therefore, remain unaffected. These are whether the 1880 receiver patent anticipates the 1891 patent, and whether the invention described in the latter patent is the invention sworn to in the original application, or an entirely different invention introduced by amendment more than two years after it had been in public use. In regard to the first point, the apparatus described in the 1880 patent is identical with that of the 1891 patent, even the cut in the latter patent specification being a reproduction of that in the earlier one. The question at issue is, therefore, whether two patents can be obtained on two separate functions of an identical apparatus—in this case, one function being that of a receiver (which has never been used) and the other, that of a transmitter.

The second point will most probably be the weaker one, as in all probability whatever changes were introduced into the application were made under the forms of law, and the incompetency of Patent Office officials may here again come into play. The other issue, however, is distinct, and with no probability of complications entering to adversely affect its determination on merit alone. Every effort of independent telephone manufacturers should, therefore, be directed to its early adjudication. Above all, no further action by the Government in the matter should be countenanced. Its record thus far in the Berliner case is a shameful one, and furnishes a powerful argument against the socialistic theory of Government, under which all the affairs of men would be under the paternal care of Government officials.

Alternating vs. Direct Current Central Stations.

A subject of much discussion has been the relative merits of alternating and direct-current central stations, and as partizans of the latter system have usually done the discussing, the alternating-current system has generally come off second best. As alternating-current plants are built to-day, there is perhaps ample reason for the commercial supremacy of its competitor, but it does not seem to have been fully realized that the two systems have never been compared on an equal basis. If all of the natural advantages of the alternating-current system were utilized, its partizans claim that it would stand forth pre-eminent as the system for central-station work.

On the question of generator there is no doubt but that the alternating-current system is distinctly at an advantage. The absence of commutators, and in some cases of brushes and collector rings, eliminates a most prolific source of attention and expense. In efficiency the alternator is comparable with the best direct-current machine, and in mechanical convenience it is unsurpassed. Regulation is the point on which the alternate-current system has apparently been most vulnerable, but a little reflection will show that some of the conclusions that have been drawn are eminently unfair. The best regulated direct-current stations are, it will be found, composed of simple shunt machines, and no attempt at automatic regulation of any kind is made, as far as the dynamo itself is concerned. Boosters and regulating bus bars of various voltages and similar devices—but most of all ample human vigilance—are the causes of the superiority of regulation in these stations.

The alternating-current system, on the other hand, is installed with its generator compounding coil and rectifier and its transformer system, and is expected to regulate for itself, which it does to a certain extent—even better, it may be said, than would a direct-current machine under similar circumstances. Were we satisfied with a simple separate excitation and hand regulation, we would then obtain results comparative with those of the large direct-current stations. The kicking coil will do away with the necessity of the bus bars of various voltages, and separate feeders can be compounded by means of an over-rated induction motor in series with the line, which will act as a booster, and the amount of its boosting can be varied by varying the speed, in precisely the same way as with the direct-current booster, with the advantage over the latter machine that there is no commutator or brushes.

With regard to the transformer drop, the multiple-transformer system may be abandoned, and large transformer substations substituted. The booster would compound for the drop in this large transformer, which should distribute at 220 volts over the area it is to supply, and a 110-volt current obtained by the use of balance coils. When the transformer item is figured into the line expense, there is no appreciable advantage in the alternating-current system if each consumer has his own transformer, but with a large substation transformer, there is a decided saving in favor of the alternating-current system. On equal grounds, therefore, it would appear that the alternating-current system may be made to excel the direct-current system in the matter of first cost, and in the operation of its machines and in regulation there is no reason why it should not equal and indeed surpass it.

Our Leading Articles.

Whether "Special" numbers of technical journals always meet with an appreciation commensurate with the labor and expense entailed in their preparation, is a question in regard to which there is room for difference of opinion. In order to assure as far as possible a favorable verdict for the first "Souvenir" number of the AMERICAN ELECTRICIAN, its contents have been selected and prepared with a view to giving the number a distinctly permanent value. The contribution from the pen of Prof. Thurston will be found to meet this requirement in an eminent degree, being a thoroughly practical discussion of the commercial economy of the various types of steam engines under given conditions. The selection of the best type of engine for a given set of conditions is one of the most difficult to be met with in electrical engineering, for it may happen that an engine of low intrinsic economy will be more economical commercially under some circumstances than another of very high efficiency. Prof. Thurston points out the various factors that enter, and lays down a practical method for determining their resultant effect in a given case.

The article by Mr. Mershon on "Drop in Alternating-Current Lines" is the most important contribution, from a practical standpoint, that has yet been made to the subject treated. The table and chart given enable the sizes of alternating-current transmissions to be determined in a most remarkably simple manner, the effects of inductance and power factor both being included. Dr. Bell, in an article on the "Economics of Power Transmission," gives a thoroughly practical discussion of the factors upon which the success of a power transmission depends. The data included and the calculation made for a specific case, should enable anyone at all conversant with the subject to arrive at a sufficiently satisfactory conclusion concerning the commercial feasibility of any proposed ordinary electrical transmission.

Some months ago the AMERICAN ELECTRICIAN obtained and printed the opinions of American users of 220-volt lamps. The article attracted much attention at the time, as little had been known on the subject, and the unanimity of opinion in favor of 220-volt lamps was somewhat surprising. In this issue we print an article from the principal advocate in England of high-voltage incandescent lighting, which is no less enthusiastic in its terms than the opinions above referred to. This article will accomplish an excellent service if it develops greater attention to the important subject of which it treats.

The comparative accounts of central stations contained in the opening pages will, it is believed, be found of much interest. In selecting the stations to be described, those of smaller cities were alone considered, for the reason that such plants possess more of interest to the average central-station man than the elaborate installations of great cities. In each case the plant described was selected on account of being the most modern or typical of its class in the respective countries. Owing to a delay in the receipt of manuscript, a description of a typical modern German central station is not included in this number, as intended, but will appear later.

The article descriptive of the electrical industries at Niagara differs considerably from the usual Niagara article, in that it avoids hackneyed description and is confined as far as possible to details of operation. The article of Mr. Berg presents in a simple manner the principles underlying the operation of single-phase induction motors, pointing out the difficulties met with in the perfection of this type and indicating the manner in which they may be overcome. To the very little information now existing concerning the details of alternating-current operation, Mr. Raymond adds a considerable quota, gathered from his own practical experience. The somewhat great preponderance of articles on alternating-current subjects is, we believe, justified, not only by the growing importance of that branch, but by reason of the more complicated nature of its phenomena, and the greater difficulty in their understanding.

HOW TO MAKE A SIMPLE STEAM CALORIMETER.

BY M. THOS. FULLAN.

In these latter days of keen competition, it is desirable to take every advantage, and to correct all sources of loss from whatever cause. The fact that many boilers, particularly when forced or overworked, produce wet steam is well known, but the amount of this moisture, or even the fact of its existence, is not always easily determined.

Many engineers have not access to the expensive instruments for determining the same, and in view of this last fact, I herewith submit a short description, with sketches, of a very simple "throttling" calorimeter, which any engineer may construct for himself, at the nominal expense of a few pipe fittings and a steam thermometer, which may be purchased for a couple of dollars.

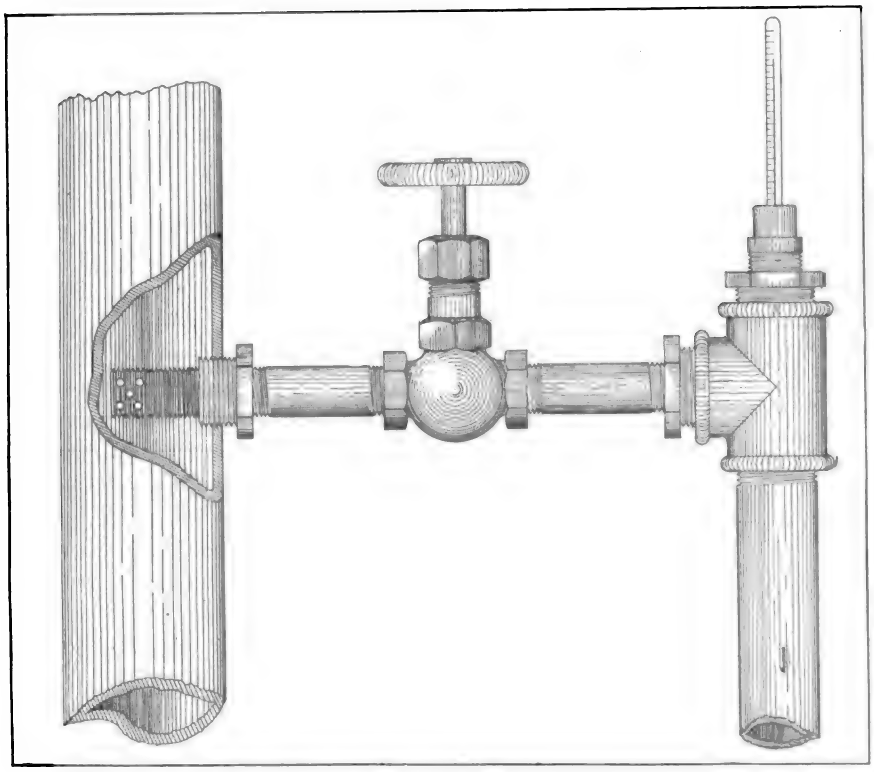


FIG. 1.—CALORIMETER CONNECTED.

Fig. 1 shows the calorimeter assembled in position for use, connected to a steam pipe; when possible, it should be connected to a vertical pipe, as shown. The body of the instrument may be made of a 1-in. T fitting, into the top of which is screwed the bushing, *B* (Fig. 2); into the bushing, *B*, is fitted the thermometer tube, *T*, which is made of brass, turned down, as shown, sufficiently thin to readily transmit heat, and the mouth of the tube is somewhat cupped. The steam pipe, *S*, made of ½-in. pipe, is threaded sufficiently long, so that after having been screwed into the bushing, *D*, it will accommodate a ½-in. cap, *C*, which is screwed on the end, making a steam-tight joint with the bushing, *D*. Into the center of the cap is drilled a small hole, about $\frac{1}{16}$ in. in diameter, countersunk on both sides, the function of which is to "throttle" the steam.

Care should be taken in obtaining, as near as possible, the best specimen of steam in the supply pipe, so it is advisable to connect up, as shown in Fig. 1, by inserting the feed pipe, *S*, the end of which is perforated, into the center of the supply pipe. If it is simply screwed in, as is ordinarily done, some of the condensed steam, which invariably exists, would, in trickling down the side, enter the calorimeter and cause an error. The exhaust pipe, which leads from the bottom of the instrument, may be of any convenient length. Fig. 2 shows other views of the thermometer tube and throttling nozzle.

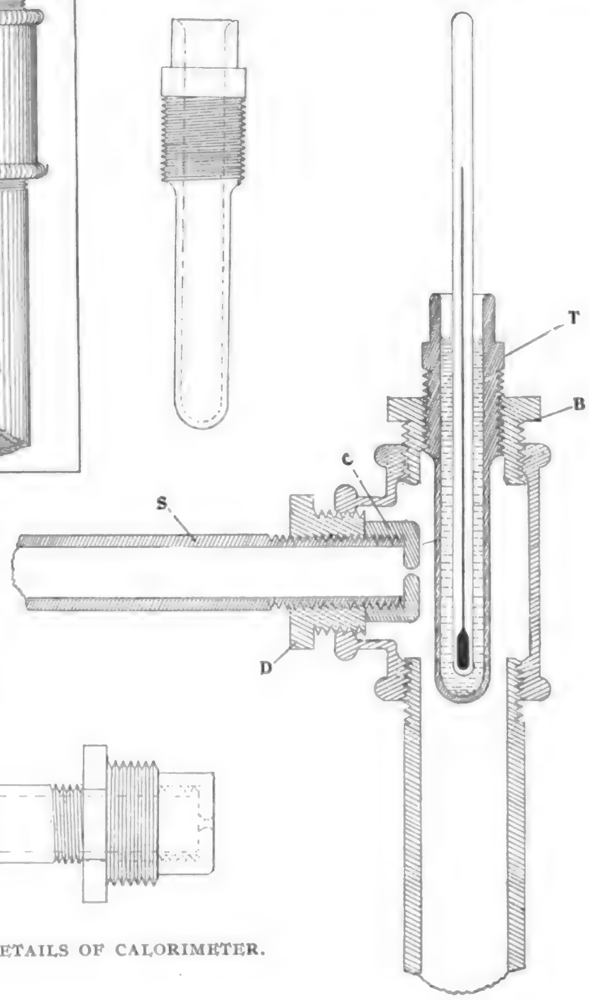
This type of calorimeter, termed "throttling" was developed by Prof. R. C. Carpenter, of Cornell University, and the principle on which it operates is as follows:

Some of the heat contained in high pressure steam is liberated when the pressure is lowered, and that heat is utilized in evaporating any water the steam may contain, and in raising the temperature of the steam bove that due to its pressure. Thus, for example, the total heat in 1 lb. of steam at 80 lbs. absolute pressure is 1177 B. T. U. (British Thermal Units), and that in 1 lb. at 20 lbs. absolute pressure is 1151 B. T. U. If, now, steam were allowed to expand without doing work on any body except itself, from 80 lbs. to 20 lbs. pressure, 26 B. T. U. would be liberated for each pound of steam. Since, at 20 lbs. pressure 954 B. T. U. are required to evaporate 1 lb. of water, we should have additional heat sufficient to evaporate 26 ÷ 954 or .027 lbs.

Now, if the original steam contained less than 2.7 per cent. of moisture, a thermometer placed in the steam would show a temperature higher than that due to a pressure of 20 lbs, which is 228 degs. F. In such a case it would be possible to compute the percentage of moisture in the steam; but if the steam contained more than the above percentage of moisture, the heat would not be sufficient to evaporate it, and the reading of the thermometer would be equal to that of the boiling point of the given temperature; thus no computation of the moisture contained in the steam could be possible. That is, a throttling calorimeter cannot be used if the steam contains much over 2.5 per cent. of moisture, but it is very convenient and accurate within its limits of operation.

To operate the instrument, connect up as shown and fill the thermometer tube with some heavy oil, cylinder oil probably being the best. Now, having inserted the thermometer, open the valve and allow steam to flow until the temperature has become constant, which will be but a short while; when the conditions are such, read the thermometer, the operation then being complete.

The quality of the steam may be then



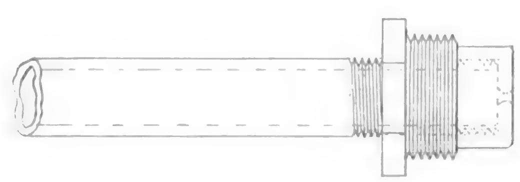


FIG. 2.—DETAILS OF CALORIMETER.

readily found by substituting in the following formula:

$Q = [H - S + .48\,(T - 212)] \div L$, where Q = quality of steam; H = total heat at atmospheric pressure; S = temperature of steam in boiler at absolute pressure (gauge pressure + 14.7 lbs.); T = temperature observed in calorimeter, that is, reading on thermometer; L = latent heat of steam in boiler at absolute pressure.

Values of *H*, *S* and *L*, may be found by

consulting steam tables found in all mechanical handbooks, and are also furnished gratis by some builders of boilers. The percentage of moisture is, of course, $100 - Q$.

As steam tables are not always convenient, the accompanying curve diagram (Fig. 3) can be used with convenience and accuracy. In this diagram the vertical divisions represent absolute steam pressures and the horizontal ones represent degrees of superheat in calorimeter. To use the curves, first find the absolute pressure of steam, which is gauge pressure plus 14.7 lbs.; secondly, determine the degree of superheat in the calorimeter which is the reading of the thermometer minus 212 degs. Then knowing these, take a point on a horizontal line corresponding to the degrees of superheat, and move in a vertical line until opposite the required absolute steam pressure. The percentage of moisture is then readily determined by interpolation of chart, as the curved lines represent percentages of moisture.

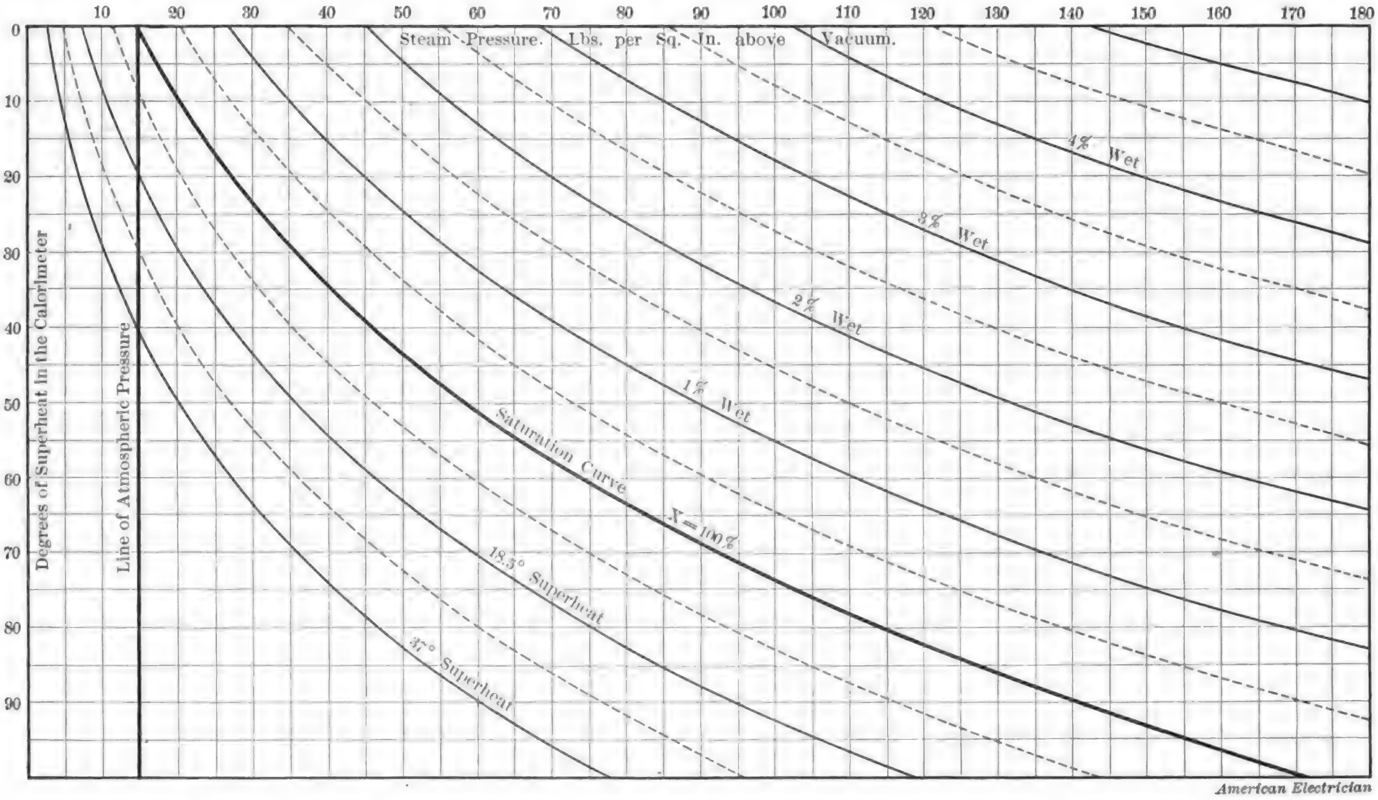


FIG. 3.—STEAM CALORIMETER CURVES.

FAULTS IN MEASURING INSTRUMENTS.

CALIBRATION OF A VOLTMETER.

In the last article some of the faults that are liable to occur in measuring instruments in common use were discussed, and calibration curves were mentioned as a means of eliminating the errors of reading. It will now be shown just how to take these calibration curves and how to plot them.

It has been mentioned that the instrument might be in error over its entire scale. The fault might be too large a reading in one place and too small in another, and no single additive or subtractive correction, such as is used to eliminate the zero error, would suffice. The calibration curve is intended to be a ready reference from which can be easily found the nature and the amount of the error for any given deflection of the instrument.

We will first consider the case of the voltmeter. It is easy to see that we may connect the erring voltmeter with one known to be correct, having the two in multiple, and apply various voltages to the combination and note and record the differences in reading.

The voltmeters would be connected as in Fig. 1, and the results of the observations could be conveniently arranged as in the following table:

Voltmeter to be Calibrated.	Standard Instrument.	Error.	Voltmeter to be Calibrated.	Standard Instrument.	Error.
5	5.1	+ .1	65	64.2	− .8
10	10.2	+ .2	70	69	−1 0
15	15.5	+ .5	75	74.7	−1.3
20	20.9	+ .9	80	78.6	−1.4
25	26.1	+1.1	85	83	−2 0
30	31.3	+1.3	90	87.8	−2.2
35	36.1	+1.1	95	92.6	−2.4
40	40.8	+ .8	100	97.5	−2.5
45	45.3	+ .3	105	102.5	−2 5
50	50.1	+ .1	110	107.6	−2.4
55	54 9	− .1	115	112.7	−2.3
60	59.7	− .3	120	117.8	−2.2

Now this table could be applied directly, for if we were using the voltmeter and it had a deflection of 45, by reference to the table we could easily find that it was necessary to add .3 volt to the reading to get the true voltage.

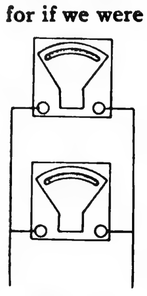


FIG. 1.—CONNECTIONS OF VOLTMETERS.

If the deflection were 47 volts, we would have to interpolate between .3 and .1 to get the proper correction, and the operation would be inconvenient if we had a great many accurate readings to make.

Therefore, it is customary to plot these results out in the form of a curve, as shown in Fig. 2. A suitable piece of co-ordinate paper is selected, and a prope space is taken in a horizontal direction as a unit of voltage, and the deflections are then marked off and appropriately numbered on a line taken as an axis of reference.

On a vertical line with each deflection is plotted the error, above the horizontal line of reference, if it is positive, and below it, if negative.

Through these points a curve is drawn, and this shows at a glance just how the error is distributed; if it is wished to interpret an intermediate deflection it is easy to do so by eye. Thus the error at 47 volts is 0, at 72 is —1.1, at 103 is —2.5.

The method of obtaining the calibration curve would be very satisfactory if we could easily obtain a standard voltmeter

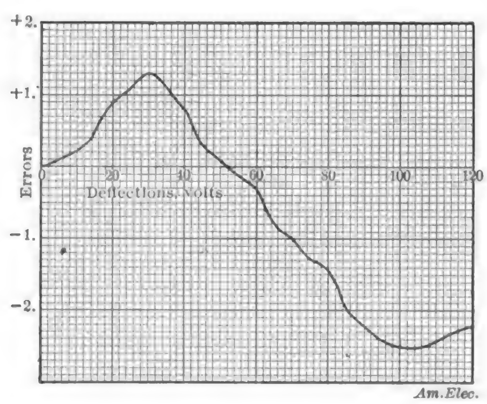


FIG. 2.—VOLTMETER-CALIBRATION CURVE.

upon whose accuracy we could implicitly rely; unfortunately this is seldom the case even for approximately accurate work, and when accurate results are to be obtained, this method of finding the errors at different points along the scale is entirely inadequate.

Fortunately it is easily possible to obtain

accurate results by means of what is known as a standard cell. One of these is known as the Clark or Carhart-Clark cell, and the difference of potential between its terminals is a constant quantity, provided it is kept at a certain temperature and no current is drawn from it. A single cell is sufficient to calibrate a voltmeter of any range. To calibrate a voltmeter there are needed a

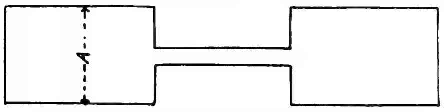


FIG. 3.—STORAGE-BATTERY PLATE.

standard cell; a source of voltage that is steady and can be absolutely controlled; an adjustable resistance of great accuracy; a delicate galvanoscope and two keys for closing circuits.

The standard cell has already been discussed. It can be made by the exercise of considerable skill, or purchased for about $10.

The problem of obtaining a steady source of current whose voltage exceeds the scale of the instrument to be calibrated is more troublesome and not always easy. A dynamo current will not answer, because its voltage is so unsteady that it would be impossible to get a reading, for, as will pres-

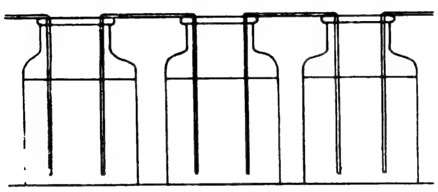


FIG. 4.—STORAGE BATTERIES.

ently be seen, to take an observation requires that the deflecting voltage be steady for one or two minutes. A sufficient number of durable primary batteries would be suitable, but expensive. If, however, this source is chosen, a dry battery or some salammoniac type will give the best service. A convenient expedient is the use of a number of small storage cells constructed as follows:

Procure one hundred wide-mouthed bottles all alike. Those commonly used to contain vaseline will answer. The entire set should not cost over $1.50. In these bottles place lead strips cut as shown in Fig. 3, the diameter, *A*, being just small enough to slip in the mouth of the bottle. Construct a little rack of ten shelves and set the bottles and their lead strips on the shelves as shown in Fig. 4. Fill each bottle two-thirds full of dilute sulphuric acid—a 10 per cent. solution—and having connected the cells in series, everything is ready to charge them. If the voltage available is 110, they should be connected across the mains in series of fifty and a water resistance should be used to reduce the charging current to about one ampere or less.

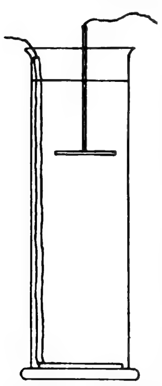


FIG. 5.—WATER RESISTANCE.

After a few hours' charging one of the plates should be of a brownish red color and the other should be gray. These colors determine the + and — of the cells and once established should always be consulted in making connections, especially when connecting to line. Such a set of cells in series should give a fraction of an ampere at 180 volts whenever wanted, and should not cost more than $3. They will of conrse, require recharging occasionally.

The next requisite, that of an accurate and adjustable resistance, is not easy to supply by makeshift. One may be constructed of a long length of fine German silver wire strung back and forth on pins on a board, but it must be calibrated by a bridge for the reference marks. It is better to use a plug resistance box that has been standardized carefully in a laboratory. This method is a most accurate one, and having gone to the trouble ot obtaining the other necessary apparatus, it would be foolish indeed to vitiate the results by the use of a resistance of which the operator is not sure.

The galvanoscope is an easier matter and many methods have been published as to how to make them. One of the mirror type is both preferable and easier to construct. The method is what is called a null method and the magnitude of the deflection with a given current is not significant. The feature to be sought is noticeable deflection with a minimum current.

To control the voltage, a water resistance in series with the battery is very effective. The terminals should be of zinc, and sulphate of zinc should be used for reducing the resistance of the column of water. A tall hydrometer jar will make an admirable water resistance and may be conveniently arranged as in Fig. 5. A rubber tube should surround the wire passing to the lower terminal. The other necessary appliances are simple, and therefore we pass directly to the method itself.

In the diagram shown in Fig. 6, *R* represents the adjustable known resistance, *B* the standard cell, *G* the galvanoscope, *V*, the voltmeter, *W* the water resistance, and *D* the battery of 100 cells. The voltage is regulated in large jumps by using more or less battery, and intermediate values are obtained by the use of the water resistance.

The operation is as follows: *D* and *W* are adjusted for a certain deflection of the voltmeter at which it is desired to find the error, and then *R* is adjusted so that there is no deflection of *G* when *K* is pressed. The observations are then complete. The following will then be true:

The current in *R* will be equal to the voltage at its terminals divided by *R*. The voltage at the terminals of *R* is evidently that of the standard cell and may be represented by *E*. Then the current equals $\frac{E}{R}$. It is evident that this current flows also in the voltmeter, *V*, and if *r* be the resistance of that instrument, then the voltage at its terminals equals *r* times the current $\frac{E}{R}$ or $\frac{rE}{R}$; *r E* and *R* are all known quantities, and replacing them by the figures they represent, the true voltage at the voltmeter terminals can be calculated. This may be compared with the actual deflection and the error ascertained.

There are several precautionary measures to be taken in such a test as this. The standard cell must be at its standard temperature or its voltage will have to be corrected. This is best obtained by immersing it in water of the proper temperature or so nearly that the correction may be neglected. For extremely accurate work both the temperature of *R* and of the cell must be taken and suitable corrections applied. It is well also to add that satisfactory results cannot be obtained from this or any other refined method unless it is intelligently applied and pains taken to secure accuracy; otherwise as good results can be obtained from a guess.

A large current either drawn from, or forced through, the standard cell, will seriously injure it, and to avoid danger of this it is best to assume the voltmeter reading, *V*, to be correct and calculate backwards for the proper value of *R* by the formula

$$R = \frac{rE}{V}$$

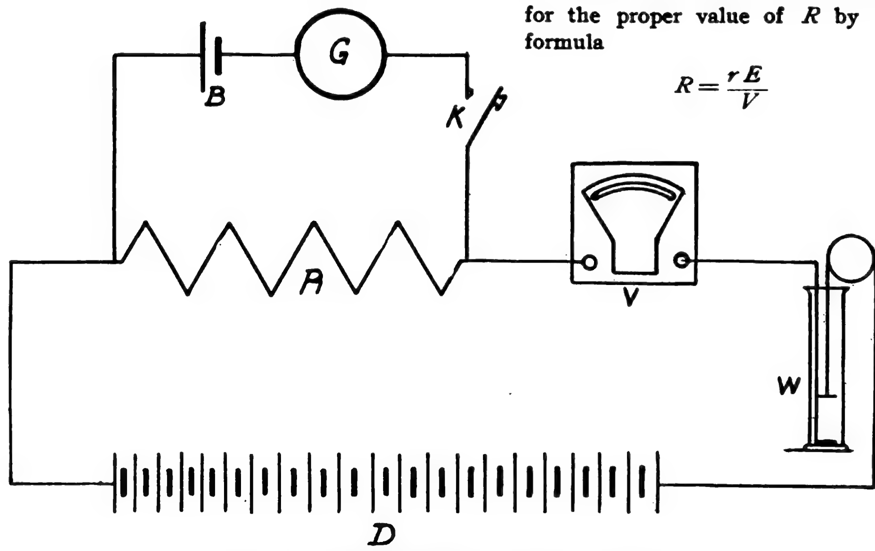


FIG. 6.—CONNECTIONS FOR CALIBRATING.

Then balance will be nearly attained at once if the error is small and there is less danger of straining the cell. The key, *K*, should even then be cautiously closed and *R* should be adjusted for zero deflection of *G*. In this way a series of readings can be made from which a calibration curve can be plotted. The method is, of course, rather tedious, but it has the accuracy of a standard method, which indeed it is.

INTERIOR WIRING.

PRACTICAL INSTALLATION.

The previous articles in this series have been devoted to first principles almost exclusively. In the following sections it will be endeavored to set forth some of the practical difficulties encountered in interior wiring and the methods of obviating them.

Interior wiring can be divided into five different systems—cleat and knob, moulding, flexible conduit, brass-armored conduit and iron-armored conduit construction. These systems will be so discussed in the above order.

Cleat aud knob construction is the cheapest of all methods, and is used in both con-

FIG. 1.—PORCELAIN CLEAT.

cealed and open work. In concealed work no attention need be paid to symmetry of disposition of the wires, but extreme care must be paid to safety. The wire is strung from insulator to insulator in inaccessible places, and can never be examined or renewed without tearing down the walls which conceal it. In case an electric fire should start, it would be in the worst possible place —in the walls of a lath and plaster construction—and it may be mentioned in passing that concealed cleat and knob work is never used for anything but lath and plaster work to any great extent.

The insulators should be of sound glazed porcelain not liable to crack under screw pressure. It is very poor economy indeed to buy poor porcelain, for the breakage wipes out the difference in cost, and the job when completed is very inferior. Cleats should be of a design such that the upper and lower cleats of a pair are exactly alike, thus doing away with the necessity of two different kinds of cleats, which would lead to annoying complications.

The knob insulators may be of the grooved

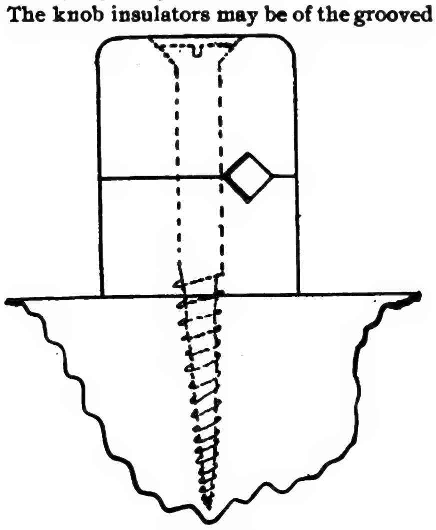
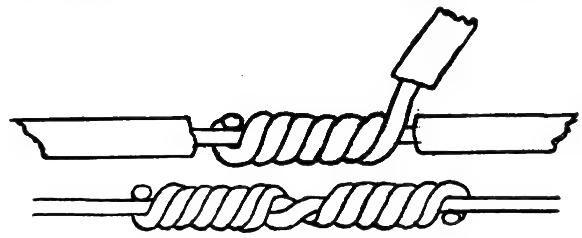


FIG. 2.—PORCELAIN KNOB.

pattern and the wire secured by tying. The writer, however, strongly recommends security insulators made in two parts, which by the pressure of the screw which holds the insulator in place, grasps the wire also. Such insulators as these are slightly more expensive, but the contractor must remember that labor is fully as expensive as material, and by a slight improvement in material the labor can be greatly abridged and a very much better job will result. Figs. 1 and 2 show a cleat and knob which are typical of those just mentioned, and are found very satisfactory.

The wire should be selected with reference to its mechanical strength of insulation. Rubber-covered wire is now insisted upon by the insurance rules, which prescribe such exacting tests that no other wire would fulfill the conditions. In the writer's opinion this insulation is altogether higher than necessary and the mechanical abrasion of the wire is a matter of very much more importance. To test a wire in this respect, take a piece of No. 14 and holding one end firmly, twist the other round and round until either the insulation or the wire gives way. The wire should break before the insulation.

The joints in a good job of wiring should be only at the branch or top circuits. Where the distance between two points is to be spanned by a single wire, there should be no joints. Line joints are intended for pole or conduit work and have no business in an interior installation. A branch joint should be made as in Fig. 3. The insulation should be removed from the wire and the latter cleaned and scraped, and the end of the branch wire, similarly prepared, tightly



FIGS. 3 AND 4.—WIRE JOINTS.

wrapped about it with the aid of a pair of pliers. It should then be soldered securely.

Considerable discussion is rife as to the best flux to use in soldering. Acid has the advantage that the joint is almost sure to be thoroughly soldered, but the great disadvantage that surplus acid left on the joint will corrode it in time. Rosin, while it has no such corrosive influence, is not as reliable a flux, and the soldering has to be more carefully done.

For solid-core wires the writer favors acid. The completed joint should be thoroughly sponged off. The men should not be allowed to tape the joints until after they have been inspected by the foreman to see that the joint is solid and substantial and that every trace of acid has been removed. A convenient test is to rub the joint with the finger and apply to the tongue, for if acid is present it will be evident at once.

When flexible cables are used, especially if they consist of many fine wires, acid is not the proper thing to use as a flux in making soldered joints. The reason for this is that it permeates a cable in that part which is covered by insulation to the depth of an inch or so, and cannot be sponged out after the joint is complete. It will remain there until it has corroded the cable almost apart, when it is highly probable that a heavy current will complete the work and form an arc which will set the insulation on fire and possibly start a general conflagration. Rosin is the proper flux in a case like this, but it should be very carefully used or the joints will not be reliable.

In taping a joint two layers of tape should be used; the first one of soft rubber which should be kneaded into an almost solid mass with the fingers, and the second of adhesive cloth tape. Insurance rules demand that

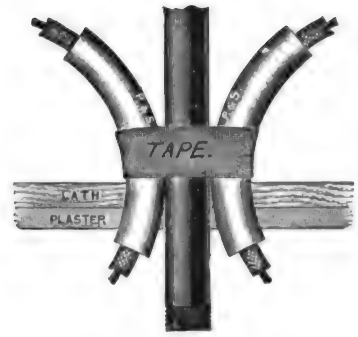


FIG. 5.—WALL BUSHING.

the joint be covered with insulation equal to that of the wire, and unless these two layers of tape are carefully applied this condition will not be attained.

When the runs are very long from building to building, it may be that piecing will have to be resorted to, and in such cases the joint shown in Fig. 4 is usually employed.

In the case of flexible cable the strands

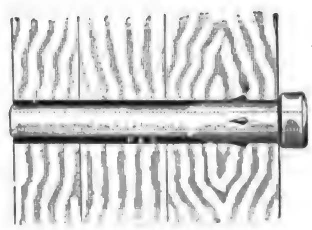


FIG. 6.—WALL TUBE.

are frayed and cut different lengths and hooked together, so that these hooks do not occur at a single point on the joint, making an unsightly bunch. The strands thus secured are tightly wrapped with copper wire, abont No. 16 B. & S. The whole mass is then sweated into a solid lump with solder. The strands should be well turned before the joint is formed.

In cleat and knob work in new buildings it is common to run the wires in the walls with regard to convenience and minimum material, and this practice is entirely admissible, provided certain precautions are observed. Pipes carrying water or steam should be avoided. If possible the wire should run over a water pipe and under a steam pipe in order to best avoid the effects of a leak. The feeders and risers in a new building should be run in chutes from basement to top floor, which should be so built that the wires are easily removable. The architect should be consulted early in the day with regard to this matter, for by a little attention much time and money may be saved.

Where the wires pass through beams or studding the hole should be bushed with porcelain tubing, and porcelain outlet tubes should be used wherever the wires emerge through lath or plaster, for this is a location at which grounds are of frequent occurrence. Figs. 5 and 6 illustrate how this should be done.

Where piping or brickwork is crossed, a flexible tubing of approved construction should reinforce the wire even though it does not touch the obstruction. To facilitate subsequent repairs, if any should be necessary, a penciled map of each circuit should be made with reference to easily located points, and accompanied by notes as to position among the studs or rafters. These sketches should be filed away with the other data concerning the contract, and may subsequently save a great deal of ripping out of lath and plaster.

Wherever the size of the wire is changed, there should be a fuse box, and for this reason the cabinet system is the most convenient for a job of concealed cleat work; otherwise the fuse boxes at the junction of the tap and feeder circuits must be brought out to an accessible position in order to permit the easy renewal of the fuse, and thus the fuse boxes would be liable to be in many inconvenient positions, and it would be impossible to locate them with any degree of accuracy except by strictly memorising the position of each one, or by making plans of the installation, as referred to in a preceding paragraph.

In the cabinet system the fuse boxes are altogether in one or more cabinets and suitably numbered; though a little more wire is used, the convenience due to this arrangement more than pays for the extra investment.

In open cleat work where everything is exposed, care must be paid to appearance. The wires should be strung straight and true and pulled as tight as whip cords and gripped by their insulators. The tap circuits should come out at right angles to the mains, and all short cuts should be avoided for symmetry's sake. The fuse boxes in such a system as this may be located directly at the joints of the tap and main circuits on the ceiling of the room, if all of the work is in an accessible position, and the object of each fuse box is evident on inspection. Before a length of wire is run one end should be tied to some rigid support and three or four men should pull upon it by jerks until it is felt to give a little at each pull, when probably all of the kinks will be removed. This should be done after the cleats have been screwed in place, because once straightened the wires should be secured in place immediately before opportunity arises for them to get kinked again.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

HOW TO PUT ON BAND WIRES.

Simple as this operation may appear, it is not always easy to put on a set of bands evenly and tightly, and the writer has seen so many cases of loose bands and bands that fail to hold, that, in his estimation, it is not only justifiable, but judicious to devote an entire article to this subject.

The proper wire to use is the first consideration, and the general rule may be at once set down that the larger the wire, that may be used with mechanical safety in the limited confines of the clearance, the better. This is based on the assumption that the clearance is seldom, if ever, large enough to admit of a wire that will be strong enough, and this is generally true. There are cases where the clearance is very great, but these are cases of either poor design or construction, and are exceptions.

It is obvious at once that a large wire will replace a number of turns of a smaller one, and thus, strength being equal, the band of large wire will be the narrower. A narrow band is a decided advantage, because the narrower the band the less the eddy currents generated therein. It is desirable for security's sake to sweat the component wires of a band together at frequent intervals with solder, and such a joint would be rapidly melted apart with excessive eddy currents. To further minimize eddy currents, the band wire should be made of a tenacious quality of German silver. The strength of this wire, while not equal to that of steel, is sufficient, while its high resistance more than counterbalances the lesser tenacity.

The insulation between the band and the armature should be both thin and tough and dielectrically secure; a spongy insulation that is liable to contract after the band is in place is sure to cause a loose band, and is to be avoided. The band surrounds the armature and is adjacent to every wire on the armature. Thus, a double thickness of band insulation, plus a double thickness of conductor insula ion, is all that separates the maximum difference of potential that the armature generates. The band insulation should at least be equal to the insulation between the conductors and the armature core. Through lack of appreciation of this fact in some cases, and lack of mechanical room in more, the band insulation is seldom made equal to this theoretical desideratum. The best material for band insulation is a composite insulation built up of fuller-board and mica, without shellac.

We now come to the actual method of applying the bands. The insulation should be cut into strips and laid in its proper place about the armature, being temporarily secured by an elastic band. After it has been satisfactorily built up, it should be tightly wound down to the armature by strong twine or copper wire, preferably the latter. This serves to hold the insulation when the permanent bands are being wound on, and also forms the insulation to the place that it is to permanently occupy.

All of the bands should be thus prepared and then everything is ready for the German silver wire. In order to give the temporary and permanent wire a strong tension, the little device shown in Fig. 2 may be used with advantage. It is almost self explanatory. The wooden blocks are preferably of maple. The device is secured to some solid support and the wire is drawn through the blocks. The tension of the wire is varied to suit the circumstances by tightening the thumb-screws.

In starting a band, all but a turn or two of the temporary band should be taken off, and the German silver wire having been wound a preliminary turn or two about the armature should be started on the band itself. The better way is to use the back gears and have some one pull on the belt, for the operation is slow and deliberate and it is often desirable to stop practically on the instant. After a few turns of the permanent band have been put on, the temporary one may be removed altogether. The joints on a band where the adjacent wires are secured together are conveniently made as in Fig. 1. A strip of very thin German silver is used. Just enough solder to secure it in place should be used and no more, the aim being to have a mechanically secure joint without making a low-resistance patch on the band that will harbor eddy currents.

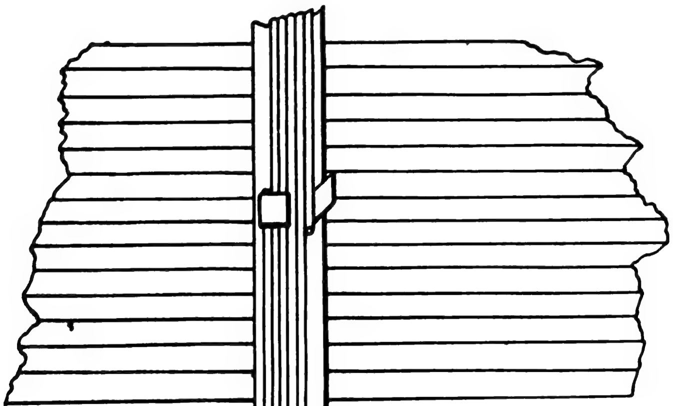


FIG. 1.—JOINTS ON BAND.

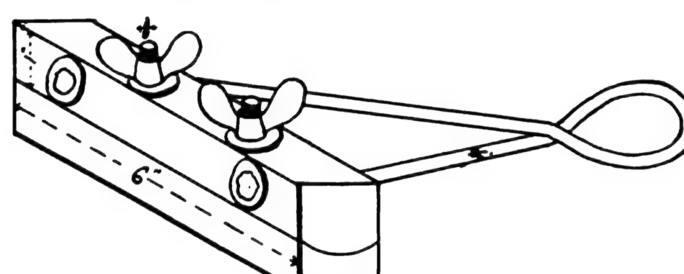


FIG. 2.—DEVICE FOR WINDING BANDS.

Having finished one band, do not cut the German silver wire, but pass at once to the next band and so proceed till the entire armature has been banded. The soldering and cutting of the ends of the wire should be left till the last.

Care should be taken to have the insulation carefully trimmed and the bands put on true, for though they may be eccentric and yet secure, lack of attention to this detail gives the completed job a decidedly amateur appearance.

In banding surface-wound armatures it is especially necessary to use the preliminary bands before attempting to put on the permanent ones, for the winding should be firmly settled against the core, thus avoiding subsequent shifting and loose bands. In the case of toothed armatures, the slots over the wire should contain a filler that is of suffi-

cient insulating properties to insulate the band. The band insulation can then with propriety be very much thinner and, in fact, only forms a seat for the band on the tops of the teeth of the armature on which it rests.

Bands wound in concave surfaces are even easier to wind than those on plain cylindrical surfaces, as the component wires seek each other and require scarcely any jointing. On convex surfaces such as on the spherical Thomson-Houston armatures, the winding is very difficult, and frequent joints have to be made, not only on individual bands, but from band to band also. These last joints are very annoying, for they form closed circuits on the armature and are a prolific source of eddy currents. In many cases it is better to loop the thin sheet-metal strip connecting adjacent bands about the band, interposing a thin sheet of insulation between, and bringing the end of the strip over the band to solder it fast to itself. This breaks the electrical joint between the strip and the band altogether.

STEAM-ENGINE HORSE POWER.

CLEARANCES AND CONSTANTS AND HOW TO COMPUTE THEM.

BY GEORGE T. HANCHETT.

Either end of an engine cylinder has two factors which are constant quantities and most important in computing tests on the engine. These are the clearance and the horse-power constant.

It will be remembered that the horse power of one side of an engine cylinder, either a head end or crank end, is computed by the following formula:

$$HP = \frac{RASP}{33{,}000}$$

where P stands for mean effective pressure, and is computed from the card; A is the effective area of the piston in square inches, S the stroke in feet, and R the revolutions per minute. Now of these factors AS and 33,000, are constant quantities and therefore the engine constant is

$$\frac{AS}{33{,}000} = K$$

It is easy to see that K is equal to the horse power the engine would exert with one pound of mean effective pressure and running at one revolution per minute. If we have K, we have merely to multiply it by the mean effective pressure and by the speed, to get the horse power. Each end of the cylinder then has two constant factors which differ slightly on account of the fact that the effective area of the crank end of the piston is reduced by the cross section of the piston rod. If the engine has a tail rod of the same diameter as the piston rod the engine constant will be the same for both ends.

To compute the constant is merely a matter of determining the values of A and S and incorporating them in the formula just given. A few words as to how to determine these factors will be useful. It is never safe to go by the rated stroke and piston diameter of the particular size of engine used. The cylinder may have been rebored or the engine, though apparently a standard product, might be a special one. In the manufacture of large machinery of any kind, changes and improvements are always being made, and the careful maker always tries these changes on his apparatus. These engines he cannot afford to do anything but sell, and accordingly they are sold and duly rated. Subsequently, after the engine becomes standardized, it may be quite different in certain details and yet be of the same horse power and rating. For this reason it is never safe to go by engine catalogues. The cylinder diameter and the stroke must be measured.

The diameter of the cylinder is conveniently measured by a large pair of inside calipers. A number of measurements should be taken on different diameters and the mean of these should be used. It is quite necessary to be accurate, for any error in this measurement is squared in the resulting constant. Horizontal engines are sometimes worn elliptical and measure longer in diameter vertically than horizontally.

Having thus secured the diameter of the circle, it is squared and multiplied by .7854, giving the area of the piston. From this must be subtracted the area of the piston rod to give the area of the piston on the crank end side. These two areas, the complete area and the area diminished by that of the piston rod, must be in square inches. They must be multiplied by the stroke measured in feet, and divided by 33,000. The measurement of the stroke is best made on the crosshead ways.

If the engine is small enough to turn over by hand it is an easy matter. Place a small steel scale on the ways as shown in Fig. 1 and turn over the engine until the scale has been pushed as far as it will go on the ways. With a sharp knife scratch a mark indicating this position as shown; repeat the operation on the other end of the crosshead and then with a pair of calipers measure the length of the crosshead between the points where it touched the scale on either end. Subtract this from the measured distance between the scratch marks on the ways and reduce the result to feet and decimal parts thereof, thus obtaining the desired quantity.

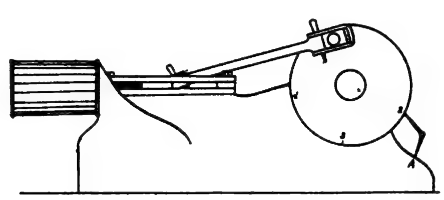


FIG. 1.—ACCURATE METHOD OF DETERMINING ENGINE STROKE.

If the engine is a very large one it will perhaps be better to measure the length of the crank and multiply it by two. This can be done easily if the crank pin and the end of the shaft are centered. Take a pair of tram points and place one in the crank pin center and the other in the center drilled in the end of the shaft and mark the distance on a piece of paper for measurement. Then measure as nearly as possible the length of the crank pin from the center drilled in the outer end to the face of the crank itself. Square this quantity and also square the distance between the crank-pin center, and the shaft center before mentioned. Subtract these two quantities and extract the square root of the result which will be one-half of the stroke and should be reduced to feet and decimals thereof as previously indicated. Or the above dimensions may be laid down as two sides of a right-angled triangle, the base of which will be the stroke.

It is very common to incorporate into the engine constant computed as just described, the speed of the engine which is assumed to be a constant—an assumption which is scarcely ever true. The constant may be qualified by stipulating the speed at which it is computed. and a table of such constants would be useful, for then the constant for the particular speed at which the engine is running could be selected and used. A curve, or rather a straight line, on co-ordinate

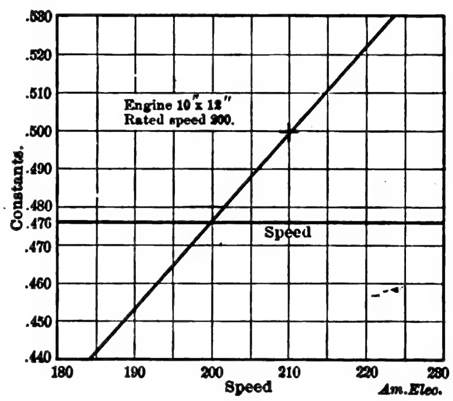


FIG. 2.—CURVE OF HORSE-POWER CONSTANTS AT DIFFERENT SPEEDS.

paper is still better and may be plotted as follows:

Select an axis of ordinates and abcissæ, and on the latter axis lay off the speeds, beginning at twenty revolutions below the standard speed and gradually increasing to a like amount above that number. Of course, it is necessary to use judgment in selecting the number of revolutions above and below, for the limits of variation of the speed are all that is necessary, and it is desirable to have the scale as large as possible. Compute the constant for the highest of these speeds and plot the point on the paper. Through this point and through the axis of abcissæ at the standard speed of the engine, draw a line and this line will be the curve of constants for all of the intermediate speeds from maximum to mimimum. Fig. 2 shows such a curve.

The clearance of the engine is the cubical contents of the space back of the piston when it has been driven to the extreme end of its stroke. It includes the irregularities in the cylinder casting, the volume of the ports and taps, and it is impossible to compute directly; it must be measured. This is commonly done by filling it with water and weighing the amount of water necessary for this purpose. From this weight the volume of the water, and hence of the clearance, can be computed. The first thing that is necessary is to set the engine on the dead-point, and to do this the method illustrated in Fig. 3 may be profitably used.

A block of wood is placed between the slides of the engine and the engine is turned till the crosshead jams upon it.

A pair of dividers is then opened a convenient distance, and a mark is made on some rotating part of the engine, such as the crank disk or fly-wheel, as shown in Fig. 3. The engine is then turned over until it jams on the other side, and a second mark is made. The distance between these marks is bisected, and that mark is turned until it comes exactly opposite the point of the dividers which made the other marks, and the engine is on the dead point. It is necessary to keep the marking dividers set to the same distance, and one leg of them should always rest on the point, A, that was first selected. Having thus gotten the en-

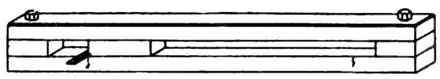


FIG. 3.—METHOD OF DETERMINING ENGINE DEAD-POINT.

gine on the dead-point, the clearance should be dried out by opening the drain cocks until the last vestige of water has disappeared. It is much better, if possible, to take off the cylinder head, for there may be pockets which will hold a considerable volume of water which should be sponged out. Close all of the openings and pour in water through the indicator cock, which should be on the top of the cylinder; if it is on the side of the cylinder it will not be suitable to this purpose. It will be necessary to pour slowly for the reason that the air in the clearance must get out as fast as the water enters, and air may be caught in pockets just as easily as water. The better way is to weigh a certain quantity of water and find out how much has been used to fill the clearance by subtractive methods, because it would be very difficult to recover all of the water from the clearance and weigh it; of course, care must be taken not to spill any water during the filling.

TABLE OF VOLUME OF WATER AT DIFFERENT TEMPERATURES.

Degs. F.	Weight of 1 cu. ft.
32	62,418 lbs.
39	62,425 "
40	62,425 "
50	62,409 "
60	62,372 "
62	62,355 "
70	62,311 "
80	62,231 "
90	62,133 "
100	62,022 "
110	61,865 "
120	61,716 "
130	61,562 "

By the use of the above table the volume of water at any temperature that is apt to be used in the engine room can be found. It is customary to express the clearance in percentage of the piston displacement. The piston displacement is the volume of a cylinder of which the effective area of the piston is the base and the stroke is the length; and in order to find the percentage of clearance the volume of the clearance in cubic inches should be divided by the volume of the piston displacement, also in cubic inches.

TELEPHONE LINES.

From the many inquiries received concerning disturbances on telephone lines, the cause of such disturbances seems to be little understood. This, however, is not astonishing in view of the explanations that may be found in some books on telephony.

Three sources of trouble will here be considered—from earth's magnetic disturbances, from what are generally known as leakage currents from grounded electrical circuits, and finally—the most important—from the inductive effects of neighboring conductors.

The first and last of these causes may be best understood by considering that the telephone circuit forms a loop into which lines of force may be introduced and withdrawn, thereby setting up inductive E. M. Fs. in the loop which may, or may not, cause disturbances according to the arrangement of the line.

Magnetic storms and similar magnetic disturbances consist in variations of the strength of the magnetic field of the earth. Ordinarily this field is constant in value, with perhaps a slight variation between the value at one hour of the day and that at another. These latter variations, however, would be at such a slow rate as not to affect a telephonic circuit. During other periods of magnetic disturbances, the fluctuations of the field of the earth may be very rapid; that is, the number of lines of force in a given area increases or decreases at a rapid rate. If the telephone circuit is within this area, these lines of force cutting in and out of the loop will set up E. M. Fs. in the circuit.

The remedy to apply in this case is to transpose the two telephone wires at more or less frequent intervals. It will be seen that if this is done and the variations of the lines of force in each of the loops formed by transposing the two conductors at intervals are the same, the electromotive force set up in the same wire will be in opposite directions in adjacent loops. That is, suppose we call one wire of the loop the outer wire and the other the inner wire; then the direction of the E. M. F. in the outer wire will be opposite to the direction in the inner wire of the next loop; and if the wires are transposed the various portions of the same wire of the line will be alternately outer and inner, and thus the E. M. Fs. will balance each other. If the wires were not transposed, the E. M. F. set up in each foot of the loop would be added together, thus producing a disturbance which may be very considerable. Of course, the application of this remedy requires an all-metallic circuit, there being no method by which this class of disturbance can be neutralized on a grounded line.

The class of disturbances from grounded circuits, such as telegraph and electric railway circuits, may be considered from two standpoints. First, we may consider that when the return current arrives at the grounded end of a telephone line, it has the choice of two paths, one through the telephone wire and the other a continuation of its path through the earth. Or, we can consider that a current flowing through the earth causes a drop of voltage between the point where it enters and the point where it leaves, or between any two points of its path. This follows from Ohm's law, drop $= C R$, where C is the current and R the resistance of the path.

If the two ends of the grounded telephone wire come within the influence of this drop, the current will be subjected to a voltage equal to the drop between such ends. This latter seems to be a better method of looking at the subject than the former or "leakage current" theory.

The only remedy for disturbances from this cause is again a complete metallic circuit, but unlike the first and third case, one return wire may be used for any number of lines, the only desideratum being to disconnect the telephone circuits entirely from the earth. It has been proposed to use a condenser on the telephone circuit to shut off currents from railway and telegraph ground-return circuits, but this would not prevent line disturbances, for the reason that such disturbances are due only to *variations* in the value of the current; if a current steady in value passes through a telephone line it would not necessarily cause any disturbance at the telephone.

The third cause of troubles is the most prolific, as they are due to the proximity of any circuit carrying a current varying in value such as lighting and telegraph circuits and neighboring telephone circuits.

Any conductor carrying a current is surrounded by lines of force which proceed out into space in concentric lines. If any closed loop is in the neighborhood of such a conductor, it will contain some of these lines of force. If the current is continuous this will not produce any effect, but if the current varies in value, the number of lines contained within the loop will vary, and each variation will produce an inductive E. M. F. which will be in one direction when the lines increase and in the opposite direction when they decrease. This inductive E. M. F. will set up a current in the circuit which, even though it may be but the merest fraction of an ampere, will affect the telephone.

There are two remedies that may be applied in this case, one of which is to make the telephone line non-inductive and the other is to make non-inductive the source that otherwise would cause a disturbrnce.

In order to make the telephone lines non-inductive, the two lines should be transposed at intervals as above explained; in this case, as in the other instances referred to, the inductive E. M. F. produced in one of the loops will balance that produced in the other loop, if the number of lines of force in each is equal.

If the number of amperes in the neighboring conductor does not vary, these loops may be made of any convenient length; if, however, the current flowing by one loop is greater or less than the current flowing by a neighboring one, the inductive E. M. F. of the one will not, of course, balance that of the other, and their value would depend upon this current. Consequently, in this case it is necessary to consider the amount of current carried in the line; at the point at which part of the current is led off the wires should be transposed, and the length of the loop extending parallel to the portion of the line carrying the smaller current should be made longer than the adjacent loop in proportion to the two currents.

It is, of course, desirable to remove the telephone wires as far as possible from the disturbing force, as then any variation from exact parallelism will produce the least effect.

In case it is necessary at any point to approach a grounded telephone conductor to a line carrying, for example, an alternating current, it will be best to approach and leave such line at right angles; a second wire may then be run back from the telephone and transposed at short intervals with the original telephone wire, its end being grounded at the point where the first wire leaves the conductor at right angles. In other words, run a dead wire back from the instrument, transpose it with the telephone conductor along the disturbing wire, and ground its end at the point where the telephone wire is taken off at right angles. This is equivalent to bringing the ground up at this point, or to making the circuit an all-metallic circuit for the distance in which it is subject to disturbing influences.

By this method a telephone wire may be kept free from disturbances, though passing at intervals in proximity with highly disturbing causes; the amount of dead wire necessary will, of course, depend upon the distance of the disturbing wire from the telephone thus protected, but this method, in many instances, will take much less wire than an entire metallic return, and yet transform an unsatisfactory service into a satisfactory one.

If the disturbing line is made non-inductive, of course, a telephone line may be strung at will. As, however, there is no probability of the owners of disturbing lines going to this expense, it will be unnecessary to consider this aspect of the question.

WHO INVENTED THE TELEPHONE?

The following letter has been received from Mr. Henry C. Strong, the query referred to being the heading of a note giving conflicting claims of Bell, Edison and Gray concerning the invention of the telephone:

"Replying to your query in the May number of the AMERICAN ELECTRICIAN, permit me to furnish you the enclosed, which I published in Washington, D. C., at the time of the telephone "hearing" before Secretary Lamar. I have full particulars concerning the Dr. Everett telephonic invention," patented May 24, 1868. I also can furnish the *details* of the "*Dark Secret*" concerning the *murder* of *Zenas Wilbur*, in Denver, Col., and much historical matter of interest to electricians. The subject has assumed vast proportions at this late day, and I am greatly interested in the development of the *future telephonic* system."

The enclosure is a two-page sheet issued in the form of a periodical publication, and entitled *The Telephone*. It contains a reprint of an article stated to have appeared in the *Journal of the Telegraph*, June 1, 1869, reprinted by that publication from the *Manufacturer and Builder*, and giving an account of the Reis telephone. The instrument described and illustrated consists of a stretched membrane having at its center a small platinum disk against which bears a platinum point adjustable by a screw. An electric circuit is made and broken with each vibration of the diaphragm. The article states that "this instrument is a German invention" and that "it is clear that no quality of tone can be transmitted, much less articulate words sent."

The other matter on the sheet consists of an extract from an article said to have appeared in the New York *Tribune* in the month of October, 1869, the article being an account of an exhibition of a telephone at Brooklyn, N. Y., and stated to have been patented Mar. 24, 1868. The extract is as follows:

"The inventor is Dr. Everett, of New Orleans, who was elected a member of the Royal College of Surgeons, at Edinburgh, some years ago. The learned doctor's theory is that sound is a triune molecule of matter—silent inertia—impulsive force—and explosive sound, and exists in all the organic atoms of the world. That with the acoustic instrument invented and patented by him, he is enabled to evolve these organic atoms of the air in such a way as to collect and convert them into two primary orders of sound—aspirate and impulsive. When thus evolved they are sent through a cylinder or tube to the wire, passing with great velocity to the distant end of the wire and into the ear of the listener. When a message is about to be sent, a tattoo is sounded by the battery, and this rings the bell so loud that it can be heard 20 ft. away. The message then follows in regular order and as they chime their intonations upon the bell they are easily interpreted by the person receiving the message from the distant transmitter."

That the above facts should be put forth as proof of the invalidity of the Bell patent is no less remarkable than the definition of sound given by the "learned doctor," which is equal to Keely's finest effort.

Central Station Finances.

In a paper read at the Milwaukee Convention of the Northwestern Electrical Association, Mr. F. S. Terry gave the following statistics, which are averages of data obtained from a large number of central lighting stations. The statistics apply to a central station representing an investment of $100,000. Such a station, on the basis of the data collected, should have a gross income of $26,500 on an average price of 15 cents per kilowatt-hour of output, which is equivalent to three-quarters of a cent per lamp-hour for a 50-watt lamp, the total annual output thus being 175,666 KW-hours. The operating expenses, including general expenses, taxes and ordinary repairs, would annually be $14,700 or about 8⅓ cents per kilowatt-hour. The earnings should be sufficient not only to pay dividends, but in addition provide a sinking fund in order to return to stockholders their original investments at the end of the natural life of the business, and the smallest amount that should be laid aside for this purpose is 5 per cent. of the capital stock or, for the station in question, $5000, equivalent to about 3 cents per kilowatt-hour. This would leave a sufficient amount to pay dividends at the rate of 6½ per cent. As to the part of operating expenses represented in lamp renewals, it is shown that with lamps at 18 cents each, if 1 cent were added to the price it would take 17 years for the additional cost to amount to 1 per cent. of the capital stock, or lamp renewals will only be 5 per cent. of the total cost of energy. While thus any probable difference in the cost of a lamp would make but a slight difference in the earnings of the central station, a slight difference in the quality would make considerable difference in the value of light to the customer. If the customer pays three-quarters of a cent per lamp-hour and a lamp burns 600 hours, he pays for the energy consumed for that lamp during its life $4.50, so that a difference of 20 per cent. in the amount of light obtained from two different lamps, which may be reasonably expected, would be a difference in value to the customer of 90 cents. By a very small expenditure, therefore, for a better lamp, the central station manager can very considerably increase the value of what he sells to his customer.

New York City Subways.

The annual report of the Board of Electrical Control of New York City, shows that on Jan. 1 of this year no less than 1926 miles of subway had been constructed, of which 951 miles were for telephone and telegraph wires, 707 miles for high-tension electric light wires, and 211 miles for low-tension electric light wires, with 57 miles of ventilating pipe. Into these subways there have been drawn and are now operated by various electrical companies, 51,032 miles of telegraph and telephone wires, 922 miles of Fire Department wires, 894 miles of wire for arc light and power service, 711 miles for incandescent service and 386 miles used by the Police Department. The subways whose construction was commenced eleven years ago, consist mainly of wrought iron pipe laid in hydraulic cement concrete, and made accessible by means of working manholes at the intersection of every block. They are further equipped with hand-boxes having covers flush with the surface of the street at the building lines along the streets, so that distribution of the current may be made wherever required along the lines of the subways, without disturbing the surface of the roadway. When the subways were first built, no provision for ventilation was made, and the necessity for it could not be foreseen. After they were placed in operation, however, explosions became frequent, usually at points where manholes were placed. Only after careful investigation of many explosions was it possible to analyze the cause, which was due to illuminating gas escaping from leaky and worn-out gas mains, collecting in the subways and being held there by their practically air-tight condition. The subway companies then provided a system of blowers at various points by which the gas was forced out by air driven under pressure through ventilating pipes placed parallel with the subways, and having apertures at the manholes; by this system, the resistance of air being greater than the pressure of gas, the entrance of the latter was prevented. This system has been an entire success.

LESSONS IN PRACTICAL ELECTRICITY

CALCULATION OF SPECIAL FORMS OF INCANDESCENT-LIGHTING CIRCUITS.

In the article on special forms of circuits in the May issue, two errors were made by

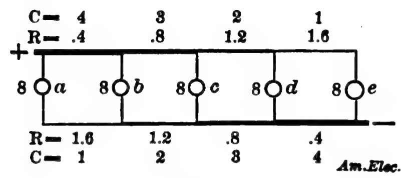


FIG. 1.

the artist in Fig. 4, which are corrected in the accompanying Fig. 1.

To illustrate the applications of the special forms of circuits described in the last issue, two of them will be applied to a practical case—the lighting of a tunnel 2500 ft. long, with 32-CP lamps spaced 50 ft. apart. In this case it was desired to have satisfactory illumination, which implied that the lamps should not be burned at more than 2½ volts from their rated voltage:—that is, 2½ volts above or 2½ volts below the voltage of the lamps. This required that the maximum drop in the circuits should not exceed 5 per cent.

One of the solutions would be a circuit like that shown in Fig. 2, in which there are three different sizes of wire, with lamps of different voltages on each of the three sections thus made.

We will assume that with the dynamo used a voltage of 127½-volts could be maintained at the terminals of the lighting circuit. On the first section, therefore, 125-volt lamps would be used, the first lamp being thus subjected to a voltage of 127½ and the last lamp to a voltage of 122½; on the second section 120-volt lamps would be used, the first and last lamp on the section being burned 2½ volts from their rated voltage; while on the third section 115-volt lamps would be used; the middle lamp in each of the three sections would, of course, receive its rated voltage. In order to have even numbers we will assume that 51 lamps are used, so that each of the sections will have 17 lamps; the lamps will be assumed to have an efficiency of 3½ watts per CP.

A 3½-watt, 32-CP lamp will require 112 watts; dividing this by the voltage of the lamps in the first section, or 125, we find that the current for each of the lamps of this voltage will be .896 amperes. Similarly, the current for each 120-volt lamp will be .9333 amperes, and for the 115-volt lamp .744 amperes. As there are 17 lamps in each section, the total current for the 125-volt lamps will be 15.2 amperes; for the 120-volt lamps 15.97 amperes; and for the 115-volt lamps 16.58 amperes.

Referring now to Fig. 2, it will be seen that the upper lead of section A will have to carry all the current for the two succeeding sections; it will also have to carry an average current of one-half of the value of the entire current necessary for its 17 lamps. Therefore, the drop on it will correspond to a current of $16.58 + 15.97 + (15.2 \div 2) = 40.15$ amperes. Similarly, the mean current of the second section (B) will be the current of section C (16.58 amperes), and the mean value of the current for its own lamps or $(15.97 \div 2)$, or 24.57 amperes in all; finally, the mean current of the last section (C) will be one-half the current of its lamps or 8.29 amperes. The corresponding sections of the lower lead will in this case, of course, carry the same currents as the upper sections.

Lamp No. 1, it is evident, will be subjected to the drop on both upper and lower lead of section A, this drop being due to the current of 40.15 amperes flowing in this section. As the drop is to be 5 volts, from Ohm's law $R = \frac{E}{C}$, we therefore find that the resistance of the upper and lower lead of section A will be $5 \div 40.15 = .1245$ ohm; of the second section, $5 \div 24.57 = .2035$ ohm; and of the third section, $5 \div 8.29 = .6031$ ohm. As the entire length of the line is 2500 ft., the length of one section will be one-third of this or, say, 835 ft., and of the double lead 1670 ft.

Now, to determine the size of wire, this might be done by referring to a copper wire table, but it will be more satisfactory to obtain it directly as follows:

The resistance of 1670 ft. of wire, if it had a cross sectional area of 1 circular mil, would be $1670 \times 10.6 = 17{,}702$ ohms, 10.6 ohms being the resistance of one mil-foot of copper. We have found above the actual resistances of the various sections, and in order to produce the given drop of 5 volts, the circular mils must be increased in the ratios of 17,702 ohms to these resistances. Dividing, therefore, 17,702 by the resistances we will get the circular mils. Performing the operation, we find the circular mils of the first section are $17{,}702 \div .1245 = 142{,}300$, corresponding nearly to No. 00 wire; that of the second section we similarly find to be 86,980 circular mils, corresponding nearly to No. 1 wire; and of the third section, 29,350 circular mils, corresponding nearly to No. 6 wire. That is, if the initial voltage is limited to 127½, and each lamp is not to experience more than a maximum of 2½ volts variation from its rated voltage, the 2500 ft. of circuit would be divided into three portions, the first consisting of No. 00 wire and carrying 125-volt lamps; the second section of No. 1 wire and carrying 120-volt lamps; and the third section of No. 6 wire and carrying 115-volt lamps.

By reference to a wire table it will be found that the respective weights of 1670 ft. of Nos. 00, 1 and 6 wire are, in round numbers, 660, 420 and 130 lbs., the total thus being 1210 lbs. Were wire of the actual size calculated used instead of the nearest sizes, the total weight would be 1310 lbs.; this latter figure will be used in later comparisons.

We will now make the calculation for a circuit corresponding to that of Fig. 3. As was shown in a previous article, no matter what the drop in the circuit itself may be, the lamps situated at the two extremities of the circuit and those connected at the points where the size of wire changes, will each be subjected to the same voltage. It is evident, however, that the lamp situated midway in any of the three sections will be subjected to a different voltage, and we will now determine what this will be.

Since our dynamo is supposed not to be able to deliver more than 127½ volts at the terminals of the circuit, we will assume that 110-volt lamps will be used, which will allow us a margin of 17½ volts for drop on the circuit and on the positive feeder leading to the final lamp. Since each lamp will take 112 watts, the current at 110 volts will be 1.12 amperes per lamp, or 19.04 for seventeen lamps. (This should be 1.02 amperes, but the value given will be retained on account of the figures based upon it in the cut, and a correction applied later.) The drop in section C of the positive lead will correspond to the current passing through it to feed sections A and B, added to the mean current of the lamps connected to the section itself, or to a total of $19.04 + 19.04 + (19.04 + 2) = 47.60$ amperes. Similarly, we will find that the mean current of section B will be 28.56 amperes, and that in the left hand section, 9.52 amperes. The currents in the negative lead will have the same values, but in reversed order on the circuit.

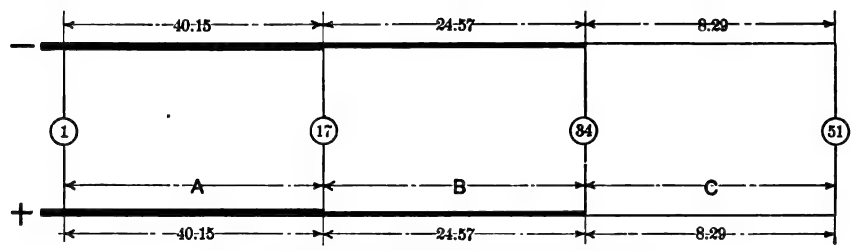


FIG. 2.—GRADUATED INCANDESCENT CIRCUIT.

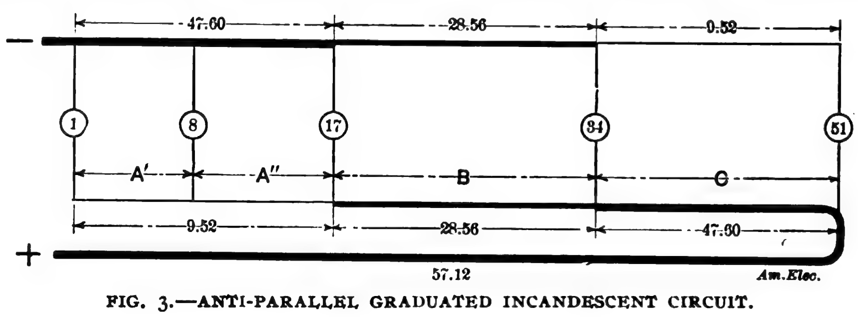


FIG. 3.—ANTI-PARALLEL GRADUATED INCANDESCENT CIRCUIT.

To see now how the land lies, we will first assume an indefinite section for the largest wire and call its resistance a. As, in order to obtain the greatest economy, the density of current in each wire should be the same, the cross section in the next largest size would be in ratio 28.56 : 47.60 or $\frac{3a}{5}$ and in the smallest section, 9.52 : 47.60 or $\frac{1}{5}a$. The resistance, of course, will be inversely as these numbers, or that of the second section will be $\frac{5a}{3}$ and of the smallest section $5a$. The voltage, as has been shown in the preceding article, will be the same at lamps 1, 17, 34, 51, but will, of course, be less by the amount of drop included, than the voltage between the terminals. The drop from the terminals to, say, lamp 17, will be equal to the drop on the sections, B and C, of the lower lead, added to the drop of the section A', A'' of the upper lead. This drop (CR) will be

$$47.60 \times a + 28.56 \times \frac{5a}{3} + 47.60 \times a =$$

$142.80\,a$. Now, what we require to know is the difference between this drop and that at

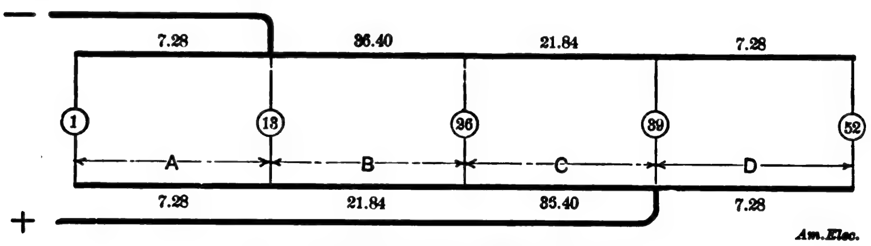


FIG. 4.—EQUALIZED FEEDER CIRCUIT.

a lamp midway on a section, such as lamp No. 8. The drop at lamp No. 8 will be that due to the currents in sections B, C and A'' of the positive leads, and A' of the negative lead. The mean current in the positive lead of A'' will be the current for the eight lamps of A', added to half the current for the nine lamps in A'', or $8.96 + (10.08 \div 2) = 14.00$ amperes. The current in section A' of the negative lead will be the current from the lamps in section B and C added to the current of the nine lamps in A'', and half the current of the eight lamps in A', or $19.04 + 19.04 + 10.08 + 4.48 = 52.65$ amperes.

The total drop at lamp No. 8 is therefore

$$48.60 \times a + 28.56 \times \frac{5a}{3} + 14.00 \times \frac{5a}{2} + 52.64 \times \frac{a}{2} = 156.52.$$

We have found the drop of 1, 17, 34 and 51 to be $142.80a$; therefore, the drop at the middle lamp in each section varies from that at the extremities of the sections by $156.52a$—$142.80a = 13.72a$, or the increase is in the proportion of 13.72 : 142.50 or 9 per cent., nearly. The error above noted in the current does not affect the percentage.

We have assumed the entire drop from the dynamo to be 17½ volts, and if half of this is on the positive feeder, we have 8¾ volts between the extremities of the circuit. The maximum variation of lamp voltage on the circuit is 9 per cent. of this, or .7875 volts; therefore, to obtain the allowable 5 per cent. variation (2½ above and 2½ below) the resistance of the circuit would have to be increased over six times, when its drop would become 55 volts, which, of course, would entail a loss of power that under most circumstances would not be allowable, and in this case the rise of voltage would be too great for the assumed limit of the machine.

An important deduction from the above calculation is that in most practical cases the difference in voltage between any of the lamps in a circuit such as that shown in Fig. 3, will not exceed an allowable amount, even though the wires of that circuit be made so small that they will heat beyond insurance requirements. In this instance the drop would be below the allowable amount if the wires were 7 numbers smaller than in the case of Fig. 2. It may sometimes happen, however, that for an out-door temporary service where the question of economy of power does not enter, and where it is desirable to economize on wire or where wire of sufficient size for circuits run on the ordinary plan is not available, this system or that described below may be used with a small amount of copper.

Fig. 4 is another form of circuit whose calculation will be illustrated in the same manner as in the case of the circuits of Figs. 2 and 3. We will assume that there are 52 lamps in order to balance the several sections. Assuming 1.12 amperes per lamp as before, the mean current in section D will be half the current of 13 lamps, or 7.28 amperes; the mean current in the positive lead of section C, will be half of the current for its 13 lamps, added to the current for the lamps in sections B and A, or $7.28 + 14.56 + 14.56 = 36.40$ amperes; the mean current in section B will be half the current of its own lamps added to the current for section A, or 21.84 amperes; the current in section A will be the same as in section D. A similar calculation will give the currents for the corresponding sections of the negative lead.

Calling a the resistance of the length of wire equal to the length of a section, the drop to lamp 52 will be $7.28a$ on the positive lead and $7.28a + 21+.84a\ 36.40a$ on the negative lead, or $72.80a$. Similarly, the drop to lamp 39 will be $58.24a$; to lamp 26, $72.80a$; to lamp 13, $58.24a$; and to lamp 1, $72.80a$. By calculating in a similar manner for other lamps it will be found that $72.80a$ is the highest drop on the circuit, and $58.24a$ the lowest, so that the largest variation in voltage is $72.80a$—$58.24a$, or $14.56a$; that is, the maximum variation of voltage is one-fifth of the highest circuit drop or the drop between the feeder terminals. If, therefore, we allowed 5 volts in all (2½ above and 2½ below) the drop between terminals will be 25 volts, or almost three times that allowable.

Let us now see which of the three systems is most economical under the conditions assumed—a maximum dynamo voltage of 127½ volts and an allowable drop of 17½ volts.

The wire for the circuit of Fig. 2 has already been calculated. For that of Fig. 3, allow 8¾ volts drop in the lamp circuit; the drop between terminals we have found to be $142\ 50a$, and correcting for 10 per cent. error in lamp current, we have 138.25 as the circuit drop, which is assumed to be 8¾ volts. Consequently, the resistance, a, of the wire of largest section is 8¾ ÷ 138.5 = .063 ohm. The distance being 835 ft., a wire of 1 circular mil of that length would have a resistance of 835 × 10.6 = 8851 ohms; dividing this by .063, we find the cross-sectional area of the largest wire to be 140,000 circular mils, corresponding nearly to No. 00 wire. The next size of wire will be ⅗ of this or 84,000 circular mils, corresponding to No. 1 wire; the smallest size will be ⅕, or 28,000 circular mils, corresponding to No. 6 wire. We have allowed 8¾ volts drop for the 2500 ft., of positive feeder, which, with a current of 57.12 amperes will require a conductor of 173,000 circular mils, corresponding to No. 000 wire nearly. The entire weight of wire (calculated from the exact sizes) would be 2600 lbs.

The lamp-circuit conductors are thus of about the same size as in the case of Fig. 2, but in addition there is a positive lead 2500 ft. long of No. 000 wire. With the condition imposed by the voltage disposable for drop, the circuit therefore is less economical in this particular case than that of Fig. 2, its advantage of a very small variation between the voltage of the lamps having no commercial value. On the other hand, by bringing up the variation of drop in circuit to 5 volts, the circuit drop will become, as shown before, 55 volts, and only one-sixth of the copper will be required in the circuit. Assuming the positive feeder to be decreased in the same proportion, only 433 lbs. of copper will be required, but the total drop from dynamo will be 110 — 17½ = 92½ volts, and the total voltage would be 220. It would, of course, be much better to use 220-volt lamps on a circuit like that of Fig. 2, than to use that voltage with the circuit of Fig. 3.

In the case of Fig. 4, we have found that the drop between terminals is $58.24a$, and correcting for the 10 per cent. error in lamp current, this becomes $52.42a$, which, as before, is equal to 8¾ volts; consequently a, or the resistance of 2500 ÷ 4 = 625 ft. of wire is 8¾ ÷ 52.42 = .166 ohm.

Proceeding as before, a wire of 1 circular mil cross-sectional area and 625 ft. long would have a resistance of 10.6 × 625 = 6623 ohms; threfore the circular mils of a wire of the same length, but having a resistance of .166 ohms, is 6625 ÷ .166 = 37,750; there are 3 × 2500 = 7600 ft. of this wire which would weigh, bare, 880 lbs., the nearest gauge size being No. 5.

We thus see that the best circuit of the three considered is that of Fig. 4. Still greater economy could be obtained with it by using three different sizes of wire—one for the two feeders, another for the portion of circuit between feeders, and a third for the two end sections, the cross sections of the several wires being such that the mean density of current will be the same in each.

Finally, we will see how much copper will

be required in the case of Fig. 4 if a maximum variation of 5 volts is allowed between the lamps in circuit. We have seen that if the drop is made three times greater between terminals, we get a maximum variation lamp variation of voltage of 5 volts. If, therefore, we reduce the size of both feeder and circuit wires one-third the amount of copper becomes $880 \div 3 = 293$ lbs., while the circuit drop is raised to 25 volts, and the feeder drop to the same amount, making 50 volts, or $110 + 50 = 160$ at the dynamo. The density of the current will, however, be too great for underwriters' requirements, but this would not apply in the installation in question.

While the case here calculated is one that has come up in practice, the principal object of this article is to illustrate a rational method of calculating drops and one not requiring the use of formulas.

Letters on Practical Subjects

Calculation of Weight of Copper Wire.

To the Editor of American Electrician:

The following simple method of calculating the weights of bare copper wire may be of interest to some of your readers. Suppose we wish to know the combined weight of 500 ft. of wire of 60,000 circ. mils, 800 ft. of 110,000 circ. mils and 200 ft. of 250,000 circ. mils. Multiplying each length by its circular mils, and adding, we have 168,000,000 circ. mil-ft. Now divide this by the circ. mils of some wire whose weight per foot is known, such as No. 0000, which contains 211,600 circ. mils and weighs .6405 lbs. per ft. Dividing by 211,600, we have the equivalent of 416 ft. of No. 0000 wire, which will weigh 266.44 lbs.

Cincinnati, O. O. D. NORTON.

Hot Bearings.

To the Editor of American Electrician:

A fertile source of trouble in high-speed dynamos is a bearing of insufficient area bushed with brass. The writer has seen such a bearing work up from a comfortable temperature to a smoking condition before a man could walk the length of a 120-ft. engine room. The origin of this condition of affairs is not always the same, of course. It may be a sudden pull on a belt, causing the shaft to spring out of line, or an infinitesimal particle of grit, or again, insufficient lubrication. In these days of self-oiling journals. This trouble does not often occur.

Whatever the cause of the heating, unless it be a hard foreign substance embedded in the bushing, the only remedy that the writer has found efficacious is a liberal bath of kerosene oil, administered by pouring through the journal, followed by an equally liberal dose of Albany compound. Frequent washing out with kerosene, if the heating is obstinate, will nearly always clear out the bearing and enable the grease to reduce the temperature. Of course, any mechanical cause for the heating will not be cured by the treatment indicated, but if the trouble is not too radical in character, a night's run may frequently be completed by constant application of Albany compound and frequently cleaning out the scorched grease with kerosene.

The writer on one occasion ran a railway generator six hours with the shaft sprung out of line nearly an eighth of an inch, by just such handling. The bearing was, of course, ground out by the eccentric motion of the shaft, but this was preferable to shutting down the line for two or three hours to shift armatures.

Boston, Mass. C. W. MORGAN.

Loss in Stoppages of Electric Cars.

To the Editor of American Electrician:

Perhaps some of your readers are in possession of data showing how the power consumption of an electric car is affected by the number of stops made in traversing a certain distance. To explain clearly what I mean it will be necessay to take a specific case. If an electric car, in traveling five miles (at an average speed of ten miles per hour) makes sixty stops, and absorbs a definite amount of energy, expressed in kilowatt hours, how much less energy will be required to propel the same car, under the same conditions the same distance, but only making thirty stops?

As more power is required to start a car, by four, five or more times than is necessary to maintain it in motion, it will appear that a judicious handling of the car controller may save an appreciable amount of energy, which would otherwise be wasted by the careless and unrestricted manipulation of the apparatus. This saving of energy might be made to represent a saving in investment in both generating units and feeder cables.

What drew my attention to the matter was the great difference in the handling of trolley cars by different motormen. It seems, that if strict rules were made relative to the stopping places on the various lines, and the men were instructed in the importance of adhering to such rules, a considerable amount of energy could be saved, especially on urban roads where stops are made at very short distances.

This may seem a small matter, yet, in addition to effecting a material reduction of the maximum load in stations, intelligent handling of the cars would likewise tend to keep the load on engines and generators more steady, thereby eliminating, to a certain extent, a source of much annoyance.

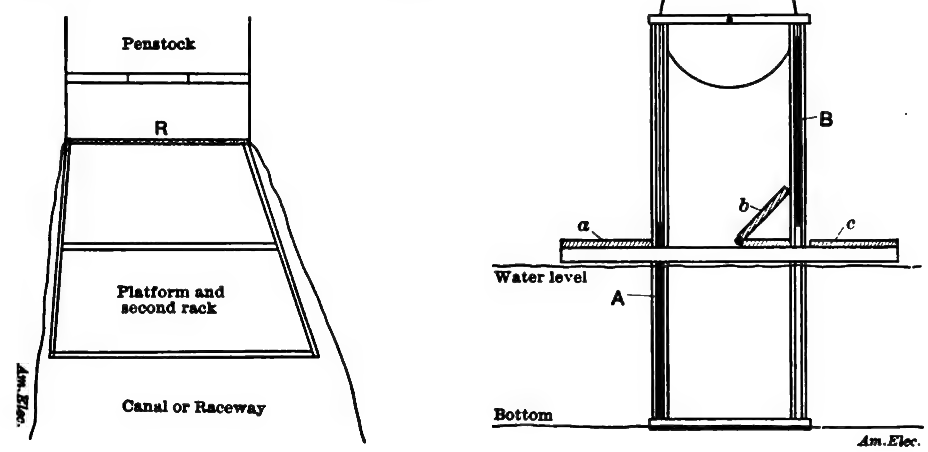
Philadelphia, Pa. S. MOUNTAIN.

Ice at Water Power Stations.

To the Editor of American Electrician:

There are probably few water-power stations located within freezing latitudes that have not been troubled more or less seriously by anchor ice. The writer submits herewith an arrangement which he found highly efficient at a water-power station which previously had been repeatedly shut down through the ice clinging to the rack and blocking the entrance to the penstock.

Wings were built out from the penstock gates into the raceway, and ten feet from the regular rack another rack of peculiar construction was placed, as indicated by the sketch (Fig. 1). This second rack was in reality a duplex sort of arrangement, shown in detail by Fig. 2, consisting of two racks suspended from opposite ends of two chains, which ran over rollers two feet in diameter. The racks were fitted very loosely in vertical guides, so that they might be raised and lowered without jamming. As shown by the sketch, they were so hung that when one was down the other was up, and the portion of the platform immediately in front of each rack was hinged like a trap door. When rack *A*, shown down by the sketch, got



FIGS. 1 AND 2.—ICE RACK.

clogged with ice, an attendant raised it out of the water, thereby lowering rack *B*; he stood on the platform, *a*, to raise the rack, and the hinged platform, *b*, was thrown back, as shown, to give room for the ice clinging to the rack. After the rack *A* was above the platform, *b* was lowered so that the ice taken off the rack would not fall into the raceway again. When rack *B* became clogged, the platform, *c*, was thrown back and the attendant raised that rack, standing on *b* to work. Of course, some time elapsed between the moment when one rack was started upward and when the other reached the bottom of the raceway, but the amount of ice which got past during the interval was easily raked from the stationary rack, *R* (Fig. 1). The arrangement was crude, and many improvements will be obvious to the average engineer, but rough as it was, it protected a 400-HP plant from being shut down by ice.

St. Paul, Minn. GEORGE N. RAWSON.

ELECTRICAL CATECHISM

128. How many wires are required for carrying three-phase currents?

Usually three. Six wires might be used if each of the three armature circuits were independent of the others and had two collecting rings. It is easy to see also that four wires might be used with the star winding, one for each circuit and one common wire for the return to the common center. But only three wires are generally used, one for each of the three collecting rings.

129. How can three separate currents be carried on three wires and yet be distinct?

Each wire practically becomes the return wire for the other two circuits. When all three currents are equal, they may be considered as neutralizing one another at the common meeting point so that no return wire is necessary. This may be understood by examining Fig. 1, in which *A*, *B* and *C* represent the three cnrrents 120 degs. apart. It may be seen that at any instant, for example, at the point marked 60 degs., the negative value of *C* just equals the sum of the positive values of *A* and *B*. In the same way, at any other instant the sum of the three currents is zero, and therefore no return wire is necessary.

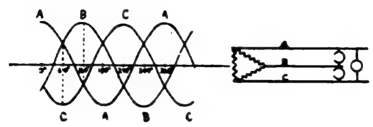


FIG. 1.

130. Where can a simple and more extended description of the three-phase system be found?

Read the article in AMERICAN ELECTRICIAN Vol. IX, page 45, February, 1897, on "Saving of Copper in Three-phased Transmission Lines."

131. Where can one find a simple and correct explanation of a method for calculating ths sizes of wire needed for electric light or power circuits?

See AMERICAN ELECTRICIAN, Vol. IX, page 134, April, 1897.

132. What sort of current is used for the field coils of alternators?

Direct current is used for alternating generators although alternating motors generally have the fields excited by alternating currents.

133. Why is it necessary to use direct currents in the fields of alternators?

The machine will refuse to carry a load unless the field is continuously excited. If an alternating current should be sent through the field, its strength would follow the variation of the current, a given pole being a strong north pole at one instant, then weakening to zero and becoming a south pole. Since a magnetic field always tends to oppose changes rather than to make them, the field would have no tendency to reverse of itself and therefore the machine would not pick up. It would be like trying to make a direct-current dynamo pick up when the field connections were reversed.

134. How is the exciting current obtained?

In some early alternators a special set of coils was wound on the alternator armature and connected with a commutator from which a direct current was obtained for the field coils. On account of the difficulty of insulating and repairing this special winding, which was usually placed under the alternating-current armature coils, this method was abandoned. Practically all the alternators in use at present take their field-exciting current from a small direct-current machine called an exciter.

135. How is the exciter generally driven?

The exciter is commonly a separate machine belted either from a pulley on the alternator shaft or from the line shaft. Frequently the exciter is mounted on an extension from the frame of the alternator and is belted from a pulley on the alternator armature shaft.

136. Is the exciter ever built with its armature on the same shaft with the alternator?

English and German makers often, if not generally, build both the exciter and alternator with the moving parts of both on the same shaft. In this country it has been more common to run the exciter at a higher number of revolutions per minute than the alternator, in order to keep down the size and cost of the exciter, since the output is proportional to the speed. A few companies in this country have, however, adopted the practice of mounting both on one shaft, thereby saving floor space, doing away with the small belt and increasing the efficiency to some extent. Fig. 2 shows one of the most recent alternators built in this way. In the Mayo machine the alternator has a stationary armature, while the field revolves. Current is taken from the exciter armature, shown at the right, to the revolving field through brushes which bear upon two collecting rings, shown at the left of the bearing.

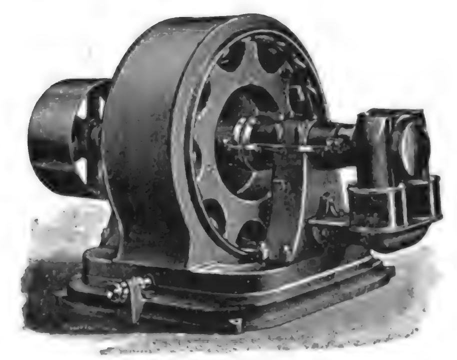


FIG. 2.

137. Is it not necessary for the armature to revolve?

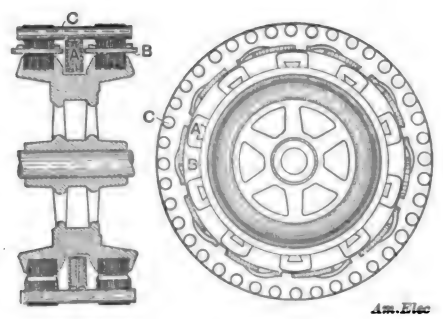
No. Most machines are so designed that the armature revolves while the field magnet is stationary, but either or both may be stationary. It is only necessary that there be relative motion between the armature wires and the magnetic field, so that the number of magnetic lines of force passing through the various coils of the armature shall be continually changing. Alternators with revolving fields generally require less magnetizing current than those with revolving armatures.

138. What sort of machines have both field and armature stationary?

The so-called inductor machines have no moving wire whatever. Examples of these are the "S. K. C." generators, made by the Stanley Electric Manufacturing Company, and described in the AMERICAN ELECTRICIAN, Vol. VIII, page 12, May, 1896, and Vol. VIII, page 75, July, 1896; also the Royal alternator, described in the AMERICAN ELECTRICIAN, Vol. VIII, page 72, June, 1896; also the Warren alternator, shown in Fig. 2. Inductor machines usually require a very small exciting field current, less than one-half of 1 per cent. of the output of the alternator.

139. How is the electromotive force induced in inductor machines!

The magnetic field always passes through a given armature coil in the same direction, but the strength of the field varies according to the position of the rotating inductor whose projections close the gap in the magnetic circuit. This may be understood by examining Figs. 3 and 4, which show a section and elevation of the S. K. C. alternator. There are four sets of armature coils, one set of two being shown in Fig. 2 (side view). The stationary field coil shown at *A*, sends the magnetic lines through the connecting bolts shown at *C*, the laminated iron projections shown in black and the rotating inductor which is cross-hatched in the sectional view. The armature coils, *B*, are placed upon the inwardly-pointing projections from the outside ring. Naturally the most of the magnetism passes around through the projecting parts as seen from the figure showing the elevation. As the inductor revolves, the projecting parts shown in the elevation cause a continual motion in the part of the field which is strongest and which follows the projecting parts of the moving portion. The strength of the magnetic field through any one armature coil therefore rises and falls as the projections pass. The two sets of coils in one ring are arranged so that the magnetic field through one set is strongest at the instant when the field through the other set is weakest. The electromotive force in one set is, therefore, 90 degs. ahead of the other, one being greatest when the other is zero. This machine therefore gives two currents 90 degs. apart.



FIGS. 3 AND 4.

Queries and Answers

What is a compound-wound armature? A. E. M.

Never heard of such an armature.

What should be the winding of the motor described in February issue in order to run it as a fan motor from a battery of 5 volts? J. P. K.

Wind the armature with No. 12 wire, two in parallel, three layers deep in slots. Wind the field with No. 10 wire, four layers deep, and connect it in series with the armature.

What are the dimensions of a medical coil? G. H. E.

Use a movable core of soft iron wires 4 ins. long and ½ in. in diameter. Wind the primary with two turns of No. 16 wire, and the secondary with a half pound of No. 36 wire.

1°. What is a bath for electroplating an object with iron? 2°. Should a compound magnet be magnetized assembled or each part separately? W. C.

1°. 150 parts of ammonio-ferrous sulphate in 1000 parts of water. To achieve good results in electroplating of any kind requires considerable skill. 2°. Each part separately.

Why does an armature burn out when two or more bars are short-circuited? A. F. R.

Because the bars also short-circuit the corresponding armature coils; the E. M. F. which continues to be generated in these sets up a current which, in coils of small resistance, may be sufficient to burn them out.

1°. What is the best primary cell for electroplating? 2°. Please give recipes for silver and nickel-plating solutions. C. E. F.

1°. Any cell of low internal resistance, such as the Daniell, Grove, Bunsen, Gordon-Burnham or Edison-Lalande. Electroplating with batteries is expensive. 2°. See page 29, January issue.

Why should incandescent lamps on Edison three-wire underground service go out more frequently during a thunder-storm than at other times? A. N. G.

We know of no reason. In some years' experience with lighting by the system named, we never knew of lamps going out during a thunder-storm or at any other time.

How should the motor described in February issue be wound to run as a dynamo at 50 volts to light four lamps? T. N.

The motor described if run as a dynamo at a slightly higher speed than that given will furnish current to light four 110-volt lamps. There would be no benefit in winding the machine for 50 instead of 110 volts.

Please give directions for making paste for the small battery used with physicians' medical coils. M. M.

Dissolve pure mercury in sulphuric acid heated nearly to boiling point; this will give a white powder which should be washed in pure water. The powder is made into a paste by the addition of a saturated solution of sulphate of zinc.

1°. What voltage would be obtained by connecting the secondaries of two 50-volt converters in series, the primaries being in parallel? 2°. In stopping a motor, should the starting box resistance be cut in before opening the switch, and why? G. M.

1°. The voltage would be doubled. 2°. Yes, for the reason that breaking the circuit otherwise would needlessly strain the insulation through setting up a high inductive E. M. F. in the motor.

1°. In treating the skin and scalp with a continuous current, which pole should be applied? 2°. What current is best for enlarging muscles? C. J. E.

We cannot answer questions relating to electro-therapeutics. No one but a trained physician is competent to deal with such a delicate organism as the human body; otherwise electrical applications are much more apt to result in harm than in good.

How can I find the henrys of a coil of wire, both with a direct and alternating current? C. H.

The henry is the unit of inductance, and therefore only applies to currents varying in value; it is the same regardless of the character of the variable current. Pass an alternating current of known frequency (n) through the coil, and measure the potential difference (E) at the terminals, and the current (C) flowing. Also, measure the ohmic resistance (R) of the coil. Let L represent the henrys:

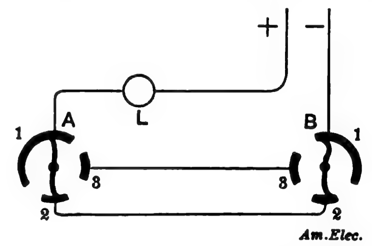
$$\text{Then, } L^2 = \left(\frac{E}{2\pi n C}\right)^2 - \left(\frac{R}{2\pi n}\right)^2$$

1°. Tesla says he will succeed in transmitting power without employing any connecting wires. How can this be done? 2°. How do inductive motors differ from other types of motors? J. H. A.

1°. Mr. Tesla has furnished no facts to support the statement attributed to him, which, therefore, remains merely a hypothesis. 2°. An induction motor is an alternating-current motor whose armature windings form a closed circuit, the armature, in fact, being the secondary of a transformer having current set up in it by the field winding acting as a primary. The armature of an induction motor does not necessarily require any external connections.

What kind of a switch and circuit are required that incandescent lights may be turned on at one switch and off at another, neither switch interfering with the usual working of the other? S. K. P.

The accompanying sketch shows how this



may be done. A two-way switch with two adjacent segments connected may be used. L is a lamp, 1, 2 and 3 are contacts of a switch, the lamp circuit connecting to the double-length contact at A and B.

1°. Please give a receipe for a dipping acid for brass and copper. 2°. How is a dry battery made? A. N.

1°. See page 139, May issue. 2°. The outer case is usually of zinc and forms one electrode. In one form the side and bottom of the case are coated with a paste consisting of 20 parts of lime, 20 parts of ammonia, 6 parts of salt and 54 parts of water. The cylindrical hole left (about half the diameter of the cylinder) contains the carbon, which is surrounded by a mixture consisting of 20 parts of manganese dioxide, 30 parts of powdered carbon and 12 parts of ammonia, which are made into a paste with water. The top is sealed with pitch.

How many sheets of tin-foil, 1 ft. square, will be needed for a condenser of 1 microfarad capacity, using two sheets of paraffined linen paper between the sheets of tin-foil? W. H.

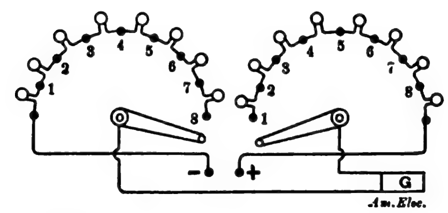
The formula for the capacity of such a condenser is $A = \frac{15458 \times t \times M}{k}$, where A is the area in square feet, t the thickness of the dielectric in inches, M the capacity in microfarads, and k the specific inductive capacity, which can be taken as 2 in the case of paraffine paper. Assuming the thickness of the two sheets of paper to be $\frac{1}{100}$ in., we have $A = \frac{15458 \times 1}{200 \times 2} = 39$ sheets 1 ft. square.

What is the accepted definition of an electrician? Can a workman in a repair shop as an armature, field or transformer winder be called an electrician? F. W. H.

Formerly an electrician was one highly skilled in the electrical art. Present usage appears to apply the word to a skilled electrical mechanic, the later term of electrical engineer applying to those having a professional education, or to men who, while not having followed a professional course of study, yet rank in qualifications with those who have. As to whether an armature winder is an electrician, the question is similar to that of "Is a lathe-man or planer-man a machinist"? If the knowledge of the first merely extends to laying on wires, or of the latter to running only one kind of machine, the answer is in the negative; if, on the other hand, either possesses a technical knowledge of the art in general, the answer would be in the affirmative.

How can a ground be located on an arc circuit when the lights are burning, using a bank of incandescent lamps? W. E. T.

The accompanying diagram shows the arrangement when a double bank is used. The levers are connected to a good ground, and as many 100-volt incandescent lamps used on each side as there are arc lamps. By moving the two levers to such a point that the lighted parts of both banks of lamps glow equally, the ground will be between the arcs corresponding to the two incandescents



on which the levers respectively rest. A single bank may also be used, and the two arc-machine terminals alternately switched on, in which case it will be better to use 50-volt lamps, owing to the greater difficulty in making the comparison. Referring to the double bank, if, for example, the ground is between arc lamps 3 and 4 and has a resistance of one 100 volt incandescent lamp (200 ohms), when the left hand lever is at 4, the other will be at 3; or if the former is at 5, the latter will be at 2. (This appeared in the May issue, but with the cut omitted.)

New Apparatus and Appliances.

PORCELAIN CEILING BOARD AND ARC CUT-OUT.

The accompanying cuts illustrate two important adjuncts for use with arc lamps—the arc ceiling-board and arc cut-out. Early practice allowed the use of wood in the construction of these appliances, but experience has shown the wisdom of making them entirely of incombustible material.

The bases are m de of best quality of glazed porcelain. Cast brass is used for connection parts. The lamp is suspended from a hook in the ceiling-board; and the lamp leads are attached to easily accessible counectors in the manner shown. The arc cut-out is a substantially built quick-break, double-pole, double-throw switch, making an absolute cut out on both sides of the lamp circuit. A cam and spring action make it impossible to hold the switch at any intermediate point between "on" and "off" so that the current is never opened on the line.

This cut-out may be used as a ceiling-board, in which case a hook for hanging the lamp is attached to its center; or it may be placed in an iron box (the hook being removed) for use out of doors. Letters cast on the box cover indicate the "on" and

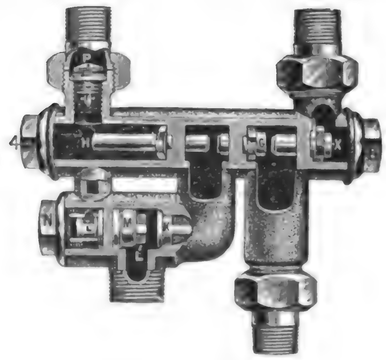
FIG. 1.—ARC LAMP CEILING-BOARD.

"off" positions of the switch. These new fittings are made by the General Electric Company, of Schenectady, N. Y.

A NEW INJECTOR.

We illustrate herewith an improvement in automatic injectors, especially designed for boilers where it is desired to carry very high steam pressures, or with ordinary steam pressures of 75 to 125 lbs. to handle a very hot water supply With the injector here shown there is obtained a working range of from 15 lbs. low pressure to 250 lbs. high pressure, and at the same time an ability to handle water at 140 to 145 degs. with 65 to 80 lbs. steam; 135 to 140 degs. at 100 lbs. steam, and 119 to 122 degs. at 150 lbs. steam. A reference to the cut will show that the construction of this injector differs from other injectors.

It will be noticed that there is an outlet from the chamber in which the delivery jet, *H*, is located, (and which is termed the



AUTOMATIC INJECTOR.

pressure chamber) around the valve, *L*, to the overflow; in other injectors there is no outlet from this chamber except into the boiler. In starting the injector, therefore, the only pressure to be overcome is the atmospheric pressure, the water passing through the jet, *H*, into the pressure chamber, and then out around the valve, *L*, which gradually closes as the current to the boiler is established; this valve is thereafter held to its seat by the full boiler pressure in the pressure chamber referred to, which also acts through this valve upon the valve, *K*, as when both the valves, *L* and *K*, are seated, the end of the valve, *L*, comes against the end of the valve, *K*, holding it firmly to its

FIG. 2.—ARC CUT-OUT OPEN.

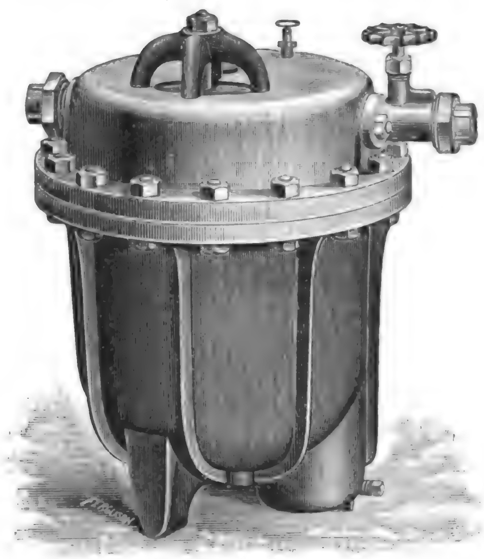
FIG. 3.—ARC CUT-OUT CLOSED.

seat by the back pressure from the pressure chamber referred to, thus accomplishiug automatically what in positive injectors requires two or three valves operated by the engineer in charge. This form of construction enables the injector to handle a very hot water supply and still be automatic. The injector described is manufactured by the Penberthy Injector Company, Seventh Street, Detroit, Mich.

ALBANY STEAM TRAP.

The steam trap illustrated herewith is a new design for use with high pressures. It consists of an outer cylindrical case containing an open-top float or bucket, the bucket being enough shorter than the outer case to allow for a vertical movement of several inches, for the purpose of positively opening and closing the discharge valve that permits the condensed steam to escape to the atmosphere. Instead of having a discharge orifice of small diameter, which quickly wears away on account of the high velocity of discharge, this trap has an opening about forty times greater in area than necessary merely for discharge purposes.

In order to prevent too rapid an escape from this large area and to give the bucket time to float upward until it has seated the



HIGH PRESSURE STEAM TRAP.

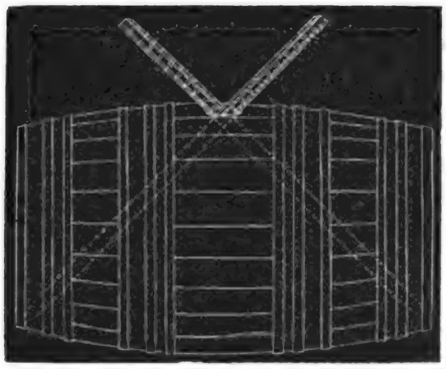
valve, there is placed in the valve casing just outside and between the valve and atmosphere, a small disk having an orifice of proper size, either $\frac{1}{8}$ in. or $\frac{3}{16}$ in. in diameter. The wire drawing and rapid wearing away occurs at this disk and not at the valve and its seat.

The valve remains on its seat until the bucket fills with water, which causes it to positively sink to the bottom of the outer shell. When in this position the valve is fully $\frac{5}{8}$ in. away from its seat, and remains in this position until such time as the water has been partially discharged from the bucket; at this time the bucket will begin to float upwards and will so continue until it has placed the valve on its seat. In other words, the valve is opened and closed at once, there being no throttling or wire drawing; this causes the valve and its seat to last for a far greater length of time than if it was opened gradually and just enough to allow the condensed water to escape, since this opening must necessarily be small, and with the great velocity between the valve and its seat, the wear would occur there instead of at the small disk.

This new type of steam trap is made by the Albany Steam Trap Company, Albany, N. Y.

GAUGE AND WANTAGE ROD.

The desirability of a simple yet accurate method of gauging the contents of an oil barrel will be appreciated by the user, and this is furnished by the simple device shown in the accompanying illustration. The method of applying the device, which is made by J. Studebaker, 2700 Emerson

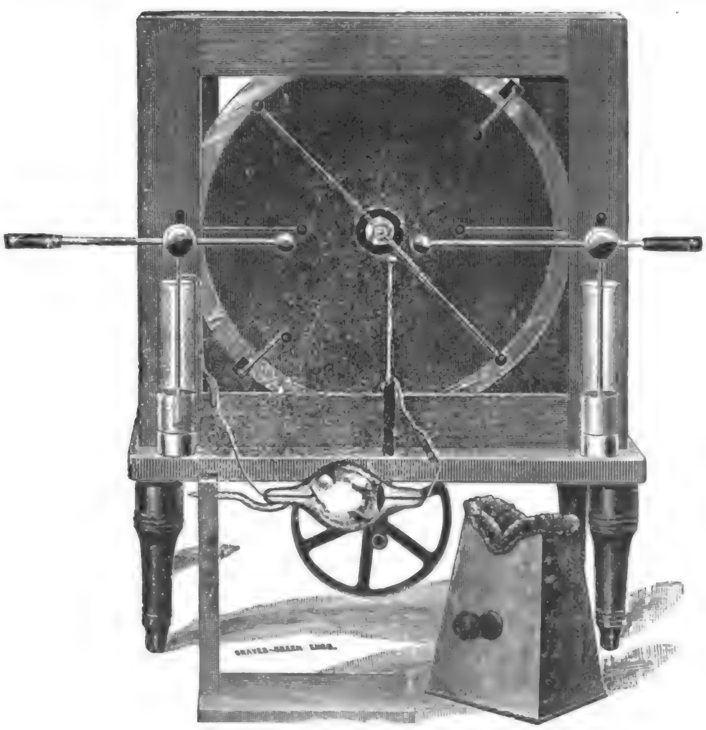


METHOD OF APPLYING GAUGE ROD.

Avenue, South, Minneapolis, Minn., is so clearly shown in the cut that explanation is unnecessary.

NEW STATIC X-RAY APPARATUS.

The machine shown in the accompanying illustration is of the Holtz type with four plates, the two revolving ones being of a special quality of hard rubber about 18 ins. in diameter. Being mounted upon ball bearings it requires very little power to run the machine at 1500 or 2000 r. p. m., at which speed sparks will be produced of from 6 to 10 ins. in length, which is sufficient for the most difficult X-ray work.



STATIC X-RAY OUTFIT.

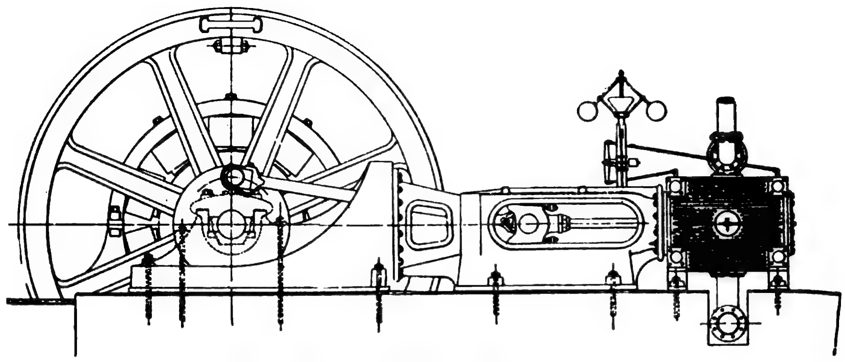
All the metal parts of the machine are nickel-plated and each machine is mounted upon a mahogany base and furnished with a handsomely finished mahogany case.

The apparatus is made by the Boston Motor Company, 17 Batterymarch Street, Boston.

HEAVY-DUTY CORLISS ENGINE.

The Corliss engine shown in the accompanying engraving is especially designed for heavy service, such as that entailed in electric railway work. The machine shown in the cut is of 400 HP, direct-connected to a 250-KW railway generator.

This type of engine combines great strength with constant regulation under a



ST. LOUIS HEAVY-DUTY CORLISS ENGINE.

wide range of load, economy of operation, and ability to operate continuously under great overload. The main frame and guide frame are made especially heavy; the guides are bored to a circle their full length by special machinery to insure their being parallel. The main pillow block is extra long and large, giving a large wearing surface for the shaft journal.

The valve gear is of the standard hook-type releasing gear, and is operated by double eccentrics and double wrist-plates, which give movement to the steam and exhaust valves independently of each other. With this new form of movement it is possible to cut off the admission of the steam to the cylinder at any point in the stroke between zero and three-quarters, and still obtain a constant compression with the independent exhaust valves. This is an important feature in electric power work or, in fact, in any service where the extremes of load are large and sudden. The valves are either single or double-ported, according to the type of engine and the speed at which it will run.

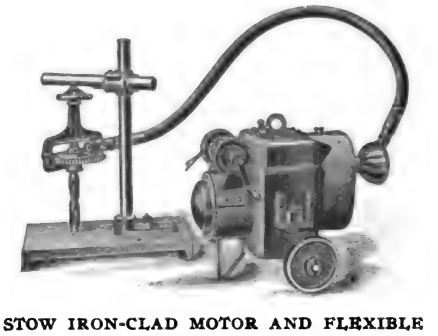
The governor is of the centrifugal heavy ball type, of special design, and is provided with a weighted lever for changing the speed of the engine, if necessary; also with an oil dash-pot to prevent chasing, and an automatic safety stop. The crosshead and crank are of open-hearth steel of 60,000 lbs. tensile strength per square inch. The crosshead has taper adjustable shoes, lined with anti-friction metal. The main shaft is of selected wrought iron, and has extra long journals.

The above engine, known as the "St. Louis Corliss," is made by the St. Louis Iron & Machine Works, St. Louis, Mo.

STOW FLEXIBLE SHAFT AND IRON-CLAD MOTOR.

The combination of the Stow flexible shaft with an electric motor is doubtless already familiar to many of our readers. Recently the manufacturers have replaced the motor formerly used by another more particularly designed to meet all of the special conditions applying, and which is shown in the accompanying engraving.

The motor is practically dust and waterproof. The frame is in the form of a hollow cube with inwardly projecting poles. In each end of the frame is a circular aperture, over which is bolted the end plates supporting the bearings. One of these is extended into a short cylinder, forming a case for the commutator and brush holder. The field coils are protected by metallic cases and can be easily removed. The motors below 2 HP are bipolar, and those of 2 HP and over have four poles. It has self-oiling bearings, mica insulation, the rheostats are protected by the iron case, and the gears are covered.

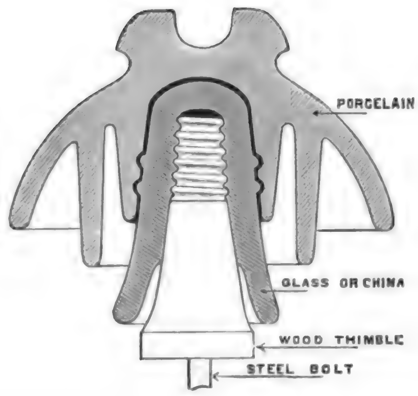


STOW IRON-CLAD MOTOR AND FLEXIBLE SHAFT.

By simply changing the end plates to bring the oil chambers below the bearings, this motor can be run in almost any position. Motors of this type are furnished for direct connection when desired, and also for electric street railway track drilling. The portable motors, as shown, are fitted with truck wheels, leg, eye bolt, side brackets, a reel, 20 yds. of insulated wire, and one set of reduction gears. By the use of a speed regulator and gears, almost any practical speed can be obtained. The makers are the Stow Manufacturing Company, Binghamton, N. Y.

THE LOCKE TWO-PART INSULATOR.

In Fig. 1 is shown the Locke two-part insulator, Fig. 2 giving a sectional view of the same. This insulator has been designed to



FIGS. 1 AND 2.—TWO-PART INSULATOR.

withstand voltages up to 50,000, the construction adopted being such as to resist in a remarkable degree the strain imposed by high voltages.

The insulator is made with an outer shell of china on account of the high surface insulating properties of that material, with which are united great mechanical strength and resistivity to electrical stress. The central portion is of glass, thus combining in one insulator the desirable properties of both glass and porcelain.

The insulator is also made of two or more shells of china; the advantage of this over one solid insulator is that the shells being made separately and only ½ in. thick, there is greater uniformity of material and more thorough vitrification than could be obtained in a solid body 1 in. thick. In addition, there are four thicknesses of glazing, which further increases the insulating qualities. The manufacturer states that repeated practical tests with 100,000 volts have failed to puncture these insulators, and they are therefore suitable for higher voltages than any yet proposed for commercial purposes.

FIG. 3.—OVAL HIGH-TENSION INSULATOR.

The body and glaze of these insulators are of simple earths alone, fused together into a vitreous, homogeneous mass under great heat. No lead or other metallic oxide entering, the glaze is not a conductor. The body and glaze being of exactly the same material fired at the same heat, the insulating qualities are uniform throughout.

Fig. 3 shows the Locke insulator used on the Niagara lines. It is oval in form, with eaves or troughs on either side to lead off the water to the remotest edge, the insulator being so fitted to the pole that the drip does not strike the cross-arm or support. The weight of this type of high-voltage insulator is about 12 lbs.

The above described insulators are made by Fred M. Locke, Victor, N. Y.

AUTOMATIC FRICTION CLUTCH.

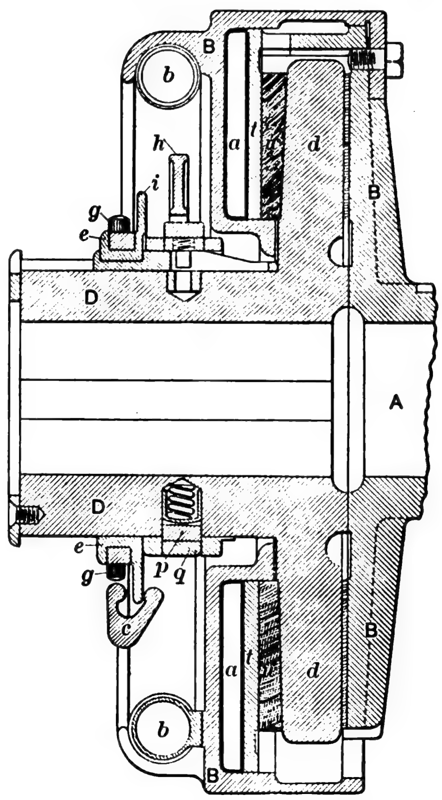
The friction clutch shown in the accompanying engraving is particularly adaptable for the high speeds at which electrical machinery is run, being free from the objection urged against other forms of clutches for this use, such as burning out, cutting or destructive jarring when thrown in, the great weight and space required, the necessity for constant care aud adjustment, and the requirement in operation of the same power they will transmit. The makers claim that the clutch illustrated will, on the other hand, transmit uniformly at any speed, all the power the shaft will transmit, and do this positively without slipping; that it requires absolutely no adjustment, will run in either direction and can be operated from any point without effort.

Referring to the sectional cut, *d* is a crated disk on the hub, *D*, filled with hardwood blocks and encased within the shell, *B B*. Within the shell, *B*, is a pressure chamber, *a*, containing a liquid-tight receptacle protected by the annular iron plate, *t*, which is movable toward and against the wood blocks, *w*, by pressure created within the chamber behind it. The shell part, *B*, carries within its periphery, protected by a flange, a collapsible reservoir, *b*, containing a non-freezing liquid, and connected at one end with the pump and at the other with the release valve, both being connected with the pressure chamber by ports through the wall of the shell.

The mechanism which causes the pump to act is carried upon the hub of the wood disk flange, being nothing more than a simple, but ingenious, shifting eccentric, connection being made with the pump lever by means of the ordinary eccentric strap. In the cut, *h* is the pump lever, *p* the eccentric ring, and *q* the eccentric strap, *c* the fingers which open and close the release valve, operated by the flange, *i*, of the shipping sleeve, *e*, which is moved by a shifter fork attaching to the trunnions, *g g*.

When it is desired to make use of the clutch, the shipping sleeve is moved toward the shell, the ring under the strap becomes eccentric, the pump acts, the release valve is closed, the pressure created in the chamber moves the plate against the friction blocks and clamps them against the friction flange; the pressure increases until the load is moved, at which point it remains until released, there thus being no loss of efficiency as in other types of clutches from the levers backing off after passing the "center."

As will readily appear, the pressure-creating mechanism being upon one element of the clutch and the means for operating this mechanism upon the other, the mechanism must operate whenever and so long as there is *relative motion* between the elements; the pressure upon the friction surfaces is therefore measured by the load itself and regulated accordingly. It is, of course, understood that when the clutch is "out" there is no action of the mechanism. It will also appear that "slip" is a physical impossibility since, could it occur, its only result would be to increase the frictional grip. The pressure being created gradually, elastically and uniformly, motion is imparted to the load without jar or strain; the clutch may be operated as slowly as desired, without injury and without danger of burning out, because the frictional surfaces are confined within a short radius of the shaft where speed is lowest, and are of ample proportions. By reason of its principle and construction, the coupling is elastic, and a defect



AUTOMATIC FRICTION CLUTCH.

in the alignment of the shafting is not destructive nor even, within reason, injurious, as the fluid pressure permits a flexibility not otherwise obtainable.

For use in connection with dynamos and motors this clutch is provided with a safety release valve, which may be adjusted to carry any load and release when the load is increased above the predetermined limit, slipping until the load again becomes normal,

when it will be carried positively as before; being, in fact, a clutch which will carry positively a certain predetermined load and no more, and adjustable as to load from zero to the limit of the shaft. This feature makes it desirable in direct-connected systems of electric lighting and power generation, while it is just as adaptable in the old line-shaft system, in which a single clutch pulley or coupling may be employed to protect the whole plant.

A special form of this clutch is designed for use in connection with the motors of electrical elevators and hoisting machinery. It is but 9½ ins. in extreme diameter and 9½ ins. in length, taking a shaft 2 ins. in diameter or less. It is used as a coupling connecting the shaft of the motor with the shaft of the worm, its purpose being to permit the motor to attain speed before taking the load, and then to take the load gradually and elastically without any abnormal demand for current. It is claimed that this will obviate the use of the rheostat in starting and also relieve the motor of strain when picking up its load.

The only wear to which this clutch is susceptible is upon the ends of the hard wood friction blocks, for which ample provision is made without the necessity of adjustment, thus extending the life of the clutch indefinitely.

The clutch described is the invention of Mr. G. M. Richards, M. E., and is manufactured by the Automatic Friction Clutch Company, 829 State Street, Erie, Pa.

EDISON FAN MOTORS.

We show herewith several 1897 types of fan motors, two of which are for use with batteries and a third for electric light circuits.

The iron-clad outfit, shown in Fig. 1, carries a 7-in. fan and is provided with a guard. The batteries operating this motor consist of three Edison-Lalande cells, type S; the motor runs at about 1200 r. p. m. on this battery. As the motor is a very efficient one, the battery will run the fan for 150 hours before needing to be recharged.

A 9-in. fan motor outfit is shown in Fig. 2. The motor is much more efficient than last year's model of the same type, running the fan at about 900 r. p. m. on a little more than 2 amperes of current when using the battery supplied with this outfit, which consist of four Edison-Lalande cells, type S.

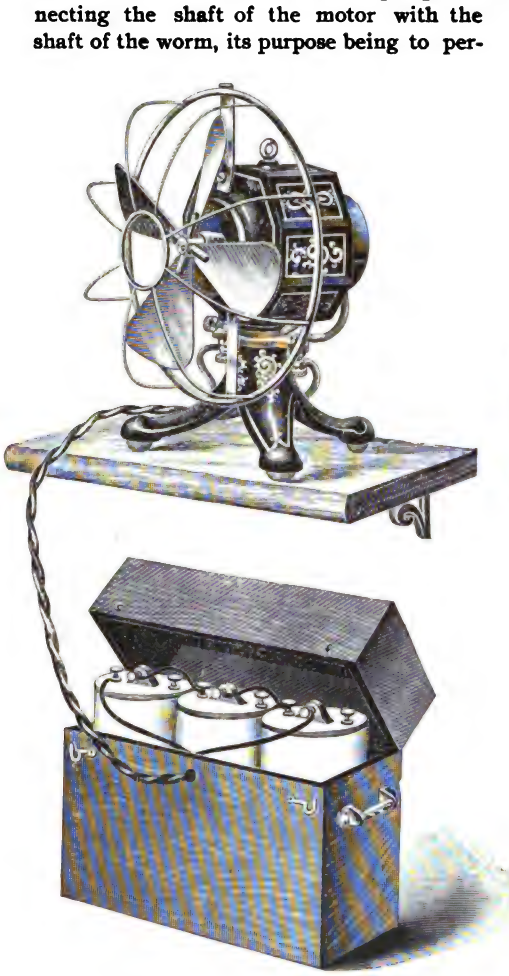


FIG. 1.—IRON-CLAD FAN MOTOR.

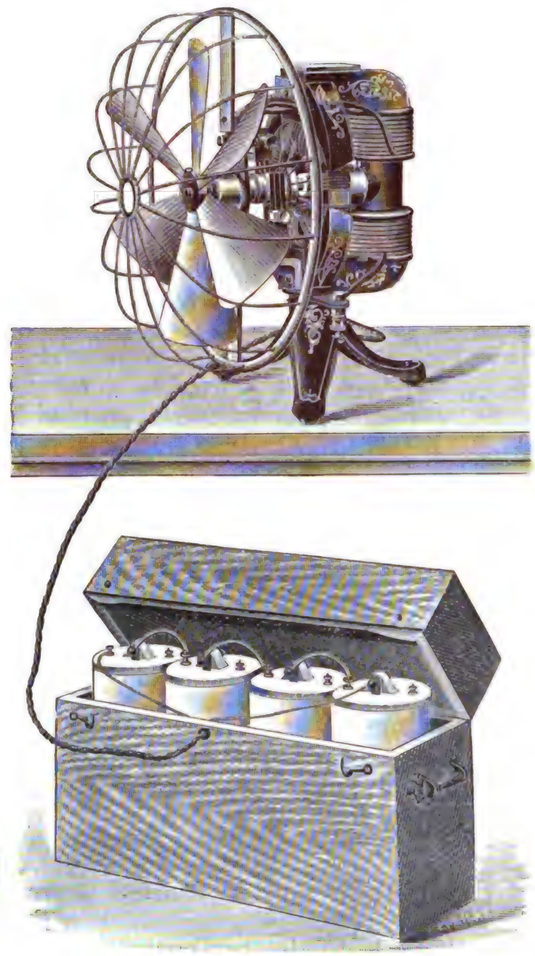


FIG. 2.—NINE-INCH FAN MOTOR.

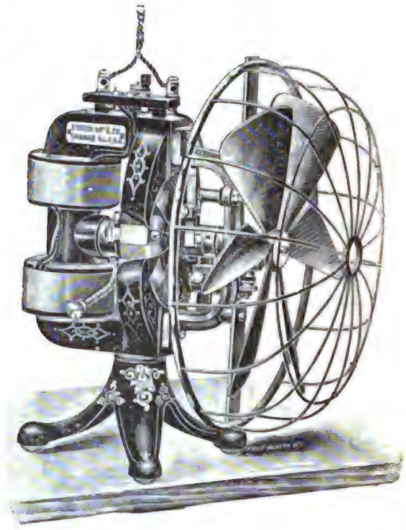


FIG. 3.—110-VOLT FAN MOTOR.

The greatest attention has been paid to the elimination of all unnecessary friction in the moving parts, and the motor as it is now placed on the market is claimed to be the most efficient battery motor yet constructed. It is provided with self-oiling bearings and the workmanship is of the highest grade.

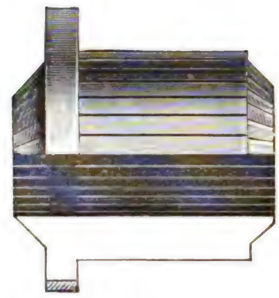
The same manufacturers have made a new departure this year, in bringing out a 9-in. fan motor (Fig. 3), to run on 110 to 120-volt direct-current circuits. This motor is similar in construction to the 9-in. battery fan motor, but is wound for the electric-light circuit. It is provided with three speeds and will run at 1400, 1700 and 2100 r. p. m. respectively. It is of high efficiency, the euergy used at these three speeds being only 36, 48 and 60 watts respectively.

All of the above motors are made by the Edison Manufacturing Company, 110 East twenty-third Street, New York.

COMMUTATOR SEGMENTS.

The accompanying illustration shows a new form of commutator segment now being placed on the market. The process of its manufacture consists in making a solid copper cylinder of the shape and size of the commutator desired. This ring is then milled from the central bore outward on radial lines through the body of the cylinder, cutting the latter into as many segments as are required in the formation of the commutator.

The cuts extend nearly, but not quite, through the rib which corresponds to the arm of the segment, leaving an uncut band of metal around the arms, sufficiently strong to hold the segments in the exact relation required for use in the commutator. All that



COMMUTATOR SEGMENTS.

is necessary in building the commutator, is to insert the mica, clamp the segments in the usual manner, and finally separate the segments with a hack saw or by turning off the solid ring of metal.

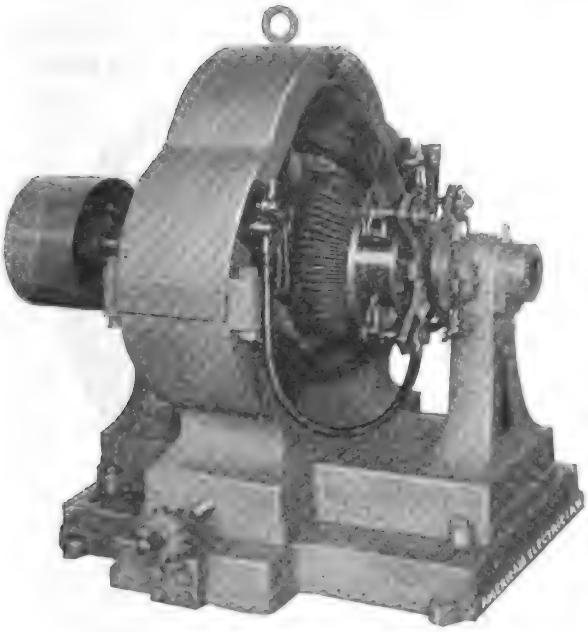
For repair work and for armatures where only a few commutators are to be built, these segments obviate the disadvantages and expense of making patterns. They are made by the Miamisburg Electric Company, Miamisburg, O.

ONONDAGA GENERATOR.

The multipolar generator shown in the accompanying cut represents a type recently placed upon the market and from which it is claimed excellent results have been obtained.

All of the parts of the machine are of generous proportion. The commutators are large and a liberal brush contact surface is allowed. Carbon brushes are used on all generators and motors. The makers guar-

antee sparkless running with all changes of load, and a low and even temperature is maintained. The armatures are of the iron-clad type, and are wound with machine-made coils, which are all thoroughly insulated and tested before being placed in the armature.



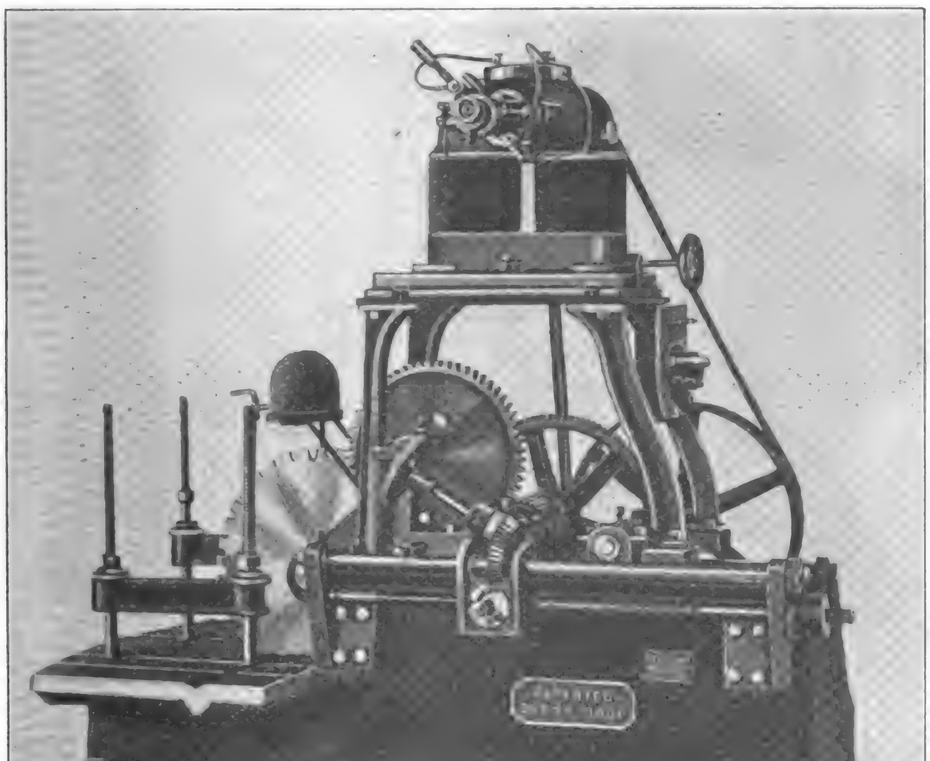
ONONDAGA MULTIPOLAR GENERATOR.

Special care is taken with the bearings, which are of the self-aligning, self-oiling type; they are provided with glass oil gauges, and so constructed that the oil will not leak out.

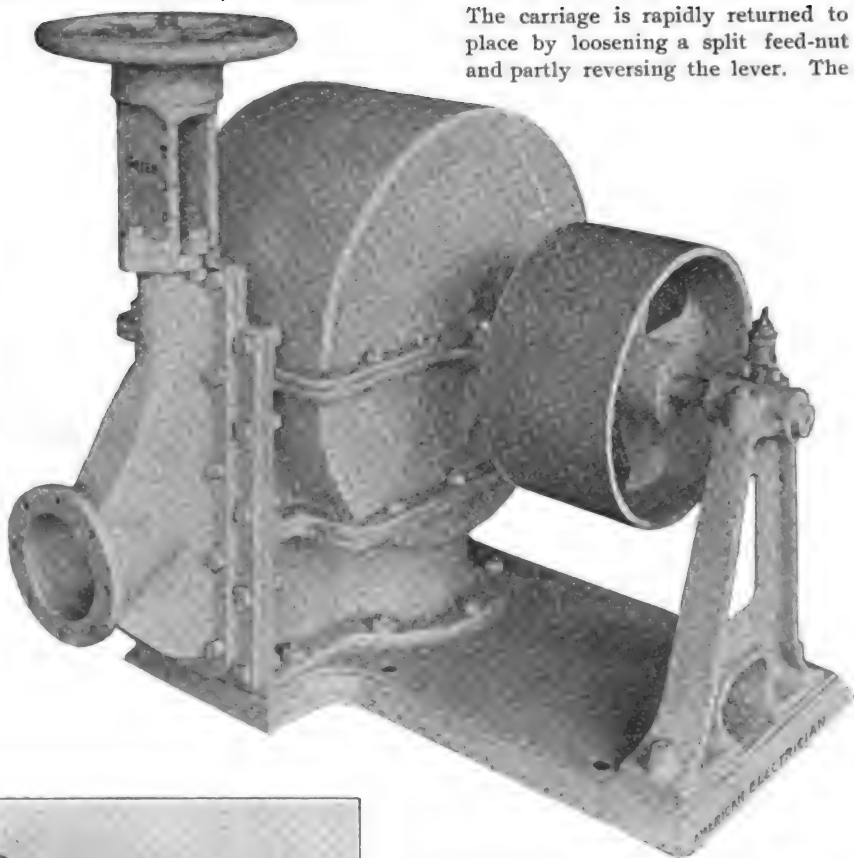
The machine described is manufactured by the Onondaga Dynamo Company, Syracuse, N. Y.

ELECTRIC SAWING MACHINE.

One of the latest applications of the electric motor is to the metal saw, as illustrated by the accompanying engraving. This machine has a capacity for cutting I-beams up to 15 ins. × 6½ ins. placed flatwise on the upper tables and edgewise on the lower tables, and at any angle from square up to 45 degs. The horizontal travel of the saw is 28 ins. The machine revolves on a circular base by the aid of a pinion and segmental rack with other suitable mechanism. The carriage is rapidly returned to place by loosening a split feed-nut and partly reversing the lever. The feeding speed may be changed while the machine is in operation. The machine has two feeding speeds, 1 in. and ½ in. per minute. The diameter of the saw blade is 25 ins. The saw may be quickly adjusted either way laterally. The above machine is made by The Q & C Company, Western Union Building, Chicago, Ill.



ELECTRIC SAWING MACHINE.



A TURBINE FOR MULE TRANSPORTATION.

A TURBINE FOR MULE TRANSPORTATION.

In many cases in the mining regions of the West and in similar locations elsewhere, the matter of transportation of machinery for a proposed plant is the most serious consideration, frequently being the snag upon which a promising scheme is wrecked. It was to meet the question of transportation to a location peculiarly inaccessible that the water wheel illustrated herewith was designed.

This water wheel is of the impulse or reaction type, called "Cascade," the specifications of which called for a wheel with no part exceeding in weight 140 lbs., and no part less than 120 lbs. The divisions were made for the purpose of light and easy transportation in a district where railroads and wagon roads are unknown. The wheel is adapted to three gradations of powers, by means of three nozzles and a gate so adjusted that 1, 2 or 3 can be used separately or together. This arrangement enables the purchaser of this particular wheel to use it for 60, 120 or 180 incandescent lights, the plant being a small one for domestic use.

As the power required is moderately steady, the wheel is operated without a governor. This type of wheel, however, is fre-

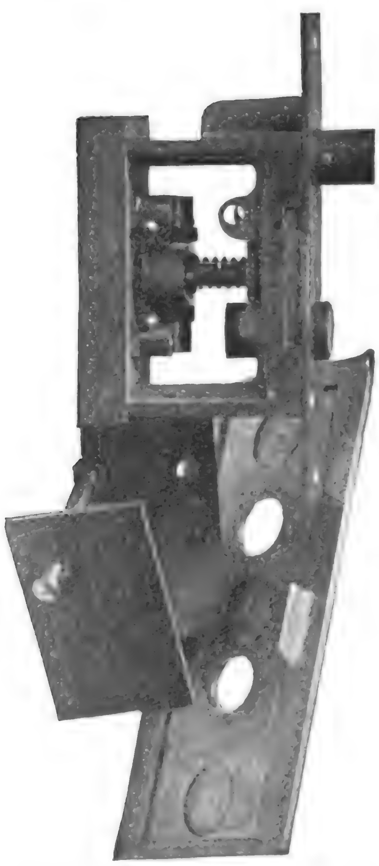
quently used for heavy powers, where often automatic regulation is necessary; in one case four of these Cascade wheels are used in a plant under 740-ft. head pressure, three of which are connected direct to the generators without belts or gears, each wheel being regulated by a sensitive governing arrangement.

This type of wheel affords an easy and comparatively inexpensive method of utilizing very high head pressures, and adds to the means of doing work at many places at great economy as compared with other means of obtaining power.

The wheel illustrated was manufactured by James Leffel & Company, Springfield, O.

PUSH-BUTTON SWITCH.

This push-button switch illustrated herewith is simple, durable and strong, the combination of these properties having only been attained through lengthy experimenting. It is made entirely of metal excepting the base, which is of slate, no porcelain being used. The casing is of solid cast-brass, and the parts have been so simplified as to obviate possibility of getting out of order. The contact is strong and firm, with a quick make and quick break.


DETAILS OF PUSH BUTTON SWITCH.

The new push-button switch is made by O. S. Platt Manufacturing Company, Bridgeport, Conn.

SWITCH-BOARD INSTRUMENTS.

The ammeter and voltmeter illustrated herewith are especially designed for switchboard use to meet the demand for an instrument which, while perfectly accurate and reliable, shall be moderate in price.

The instrements are pleasing in appearance, have jeweled bearings and contain a minimum of iron. The resistance in the voltmeters is very high and is thoroughly ventilated. All ammeters are shunted. The special features of these instruments are the proportional scale and extreme sensitiveness throughout the entire range. They can be placed close to the dynamo and are but slightly affected by the pulsatory character of a current. The range of scale is 5 ins., the diameter of case 8 ins. and the approximate weight 7 lbs.

The S. E. I. Company, Syracuse, N. Y., are the manufacturers of the above described instruments.

SWITCH-BOARD INSTRUMENTS.

C. & C. SLOW-SPEED MULTIPOLAR DYNAMO.

One of the latest types of slow-speed multipolar dynamos is shown in the accompanying cut, the machine embodying all of latest principles in multipolar design. The frame is of soft magnetic steel of high permeability and the design of the pole-pieces is such as to insure a proper flux density in the air gap under all conditions of load. The field coils are easily removable and are reinforced with a metal facing in order to avoid injury in handling. The brush holders are so supported from the magnetic frame as to be easily accessible, and are of the well-known reaction type with sensitive spring pressure on the carbons, allowing freedom of movement of the brush and securing uniform pressure of a minimum amount. The brushes are of carbon.

The armature core is built up of thin laminated plates insulated from each other, are of soft steel of high permeability and hysteretic quality, and thoroughly ventilated. The armature conductors are laid in slots in the armature core. The commutator is so secured that it is possible to remove it and the armature complete, from the shaft, thus facilitating assembling of the dynamo at point of erection. The regulation is such that the compound curve is practically a straight line, it not being necessary to move either the hand regulator or brushes at any load.

The dynamo above described is made by the C. & C. Electric Company, 143 Liberty Street, New York.


C. & C. SLOW-SPEED MULTIPOLAR GENERATOR.

WEINLAND'S TUBE CLEANER.


BOILER TUBE CLEANER.

The action of the tube cleaner illustrated herewith is rendered plain from the cut. The sharp-toothed, hardened cutter wheels effectually cut and shatter the scale on boiler tubes so that it can be removed, not merely polishing it and leaving it in the tubes, as is the case when using some types

of cleaners. The makers claim that the saving from a single cleaning will more than pay for the appliance, which is successfully used in numerous electrical plants. The manufacturers are the Lagonda Manufacturing Company, Springfield, O.

AUTOMATIC MOTOR-STARTER AND QUICK-ACTING SWITCH.

The automatic motor-starter and quick-acting switch shown herewith, are of particular service in elevator and pumping work, acting as safeguards against too rapid starting and against overloading. The automatic movement of the rheostat is accomplished by means of a small belt connected directly to the motor, whereby each revolution of the motor armature cuts out a predetermined part of the starting resistance.

By means of the quick-acting switch used in connection with the motor-starter, open-tank and pressure-tank elevators may be operated automatically with satisfaction. The combination will also be found equally useful in maintaining a certain level in the supply tanks of automatic sprinklers, etc.

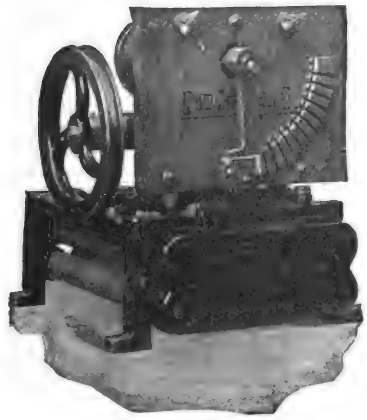


FIG. 1.—WHITTINGHAM AUTOMATIC MOTOR-STARTER.

Such electric freight elevators as allow the motor to run continuously during the time the elevator may be in service, can be more economically operated if arranged to be started and stopped from any floor as needed, and the apparatus shown enables this to be done. A rope passing up the elevator shaft and over pulleys at the top and bottom is connected to the rings of the quick-acting switch, which, in connection with automatic starter, enables any one wishing to use the elevator to safely start the motor, and afterward cut off the current consumption when it is of no service. There are instances where this saving has amounted to between $200 and $300 in one year. The automatic motor-starters are made in sizes ranging from 2 HP to 30 HP, and the switches supplied are of two capacities—for 20 and 60 amperes.

FIG. 2.—WHITTINGHAM QUICK-ACTING SWITCH.

The Whittingham automatic motor-starter and quick-acting switch are made by the Automatic Switch Company, Baltimore, Md.

"UNIQUE" ENCLOSED ARC LAMP.

One of the more recent types of enclosed arc lamps is illustrated in the accompanying cuts, one view showing the lamp closed and the other with the globe in position for trimming the carbons. The lamp has many points of interest, not the least of which are that its entire height is but 28 ins., while, with a single trimming of carbons (12 in. upper and 5 in. lower, each $\frac{7}{8}$ in. in diameter) and a current of 5 amperes, the lamp will burn from 100 to 125 hours.

A single solenoid is used for feeding and regulating, which acts through a hollow iron core surrounding the upper carbon, on a duplex-balance carbon clutch of extremely simple design, which clutches the carbon itself. There are no springs or other devices likely to get out of repair.

The side rods are telescoped into each other, there being one outer and two inner rods; by means of a simple system of latches the lamp is easily opened and securely held when closed. A resistance coiled in the canopy is so adjustable as to enable a lamp in every case to be burned at an exact voltage.

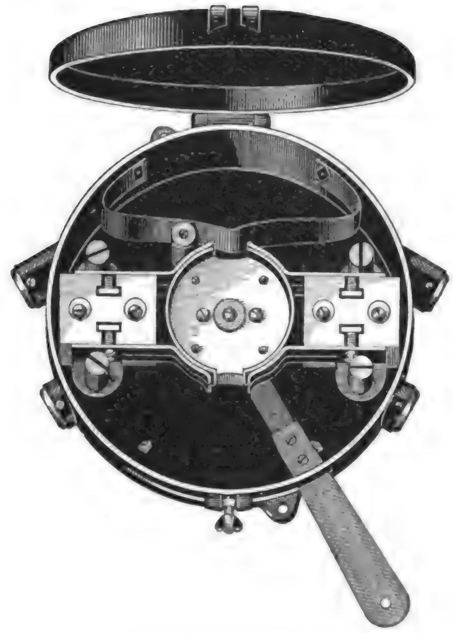
"UNIQUE" ARC LAMP, CLOSED

"UNIQE" ARC LAMP, OPENED.

The "Unique" lamp is made by the General Incandescent Arc Light Company, 572 First Avenue, New York.

ARC LIGHT CUT-OUT.

The arc light cut-out shown in the two cuts herewith, was one of the earliest in the field, and possibly the first to make any pretensions to mechanical merit in construction. It has been progressively improved and in its present form is claimed to embody every improvement that a large and widely extended use of many years has suggested. As will be seen from the illustration, the quick break is obtained by means of a spring not liable to deteriorate. The contacts are all on sturdy blocks of porcelain, and the wires enter through porcelain bushings. The cover in the latest form is hinged and of cast iron, being held closed by a bronze thumb-nut. The main characteristic of the cut-out is its durability and capacity for rough usage, even the roughest treatment being withstood throughout years. The cut-out illustrated is made by the E. G. Bernard Company, 2919 Sixth Avenue, Troy, N. Y.



ARC CUT-OUT, OPEN,

ARC CUT-OUT, CLOSED.

A NEW TYPE OF TRANSFORMER.

A type of transformer of new mechanical design and embodying many marked improvements is announced by the General Electric Company. It is known as the type H, following the preceding types in alphabetical order.

Fig. 1 shows the construction of the core, which is built up of single rectangular punchings assembled into a rectangular bundle with notched ends. The bundle, compressed under great pressure, is compactly held by a casing of insulating material, around which is wound one-half of the low-potential winding, leaving the toothed

or notched ends only obtruding. Around this winding is an insulating wrapping, and over it one-half of the high-potential coil is wound. Two such cores and sets of coils placed side by side with the ends of the cores interlocked into another set of rectangular punchings, complete the interior construction of the transformer.

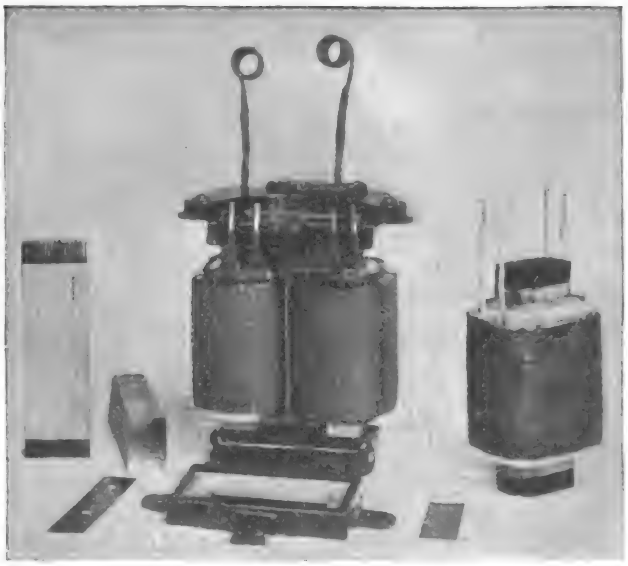
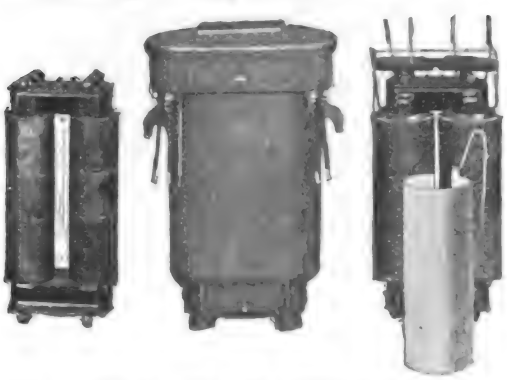


FIG. 1.—SHOWING CORE AND WINDING, TYPE H TRANSFORMER.

No iron being wasted, a high grade expensive iron can be, and is, used. This would be impossible with the usual wasteful punching if the transformer is to sell at a reasonable price and still have the very low core losses of the type H. Moreover, in



IG. 2.—10-KW TYPE H TRANSFORMER, SHOWING PROTECTIVE EARTH SHIELD.

FIG. 3.—TRANSFORMER COMPLETE, 1500, 1000 AND 600 WATTS.

the method of compression of the core and the winding of the copper, no small saving in copper is effected, there being none of the waste space between coils and iron found in the usual transformer. This saving also tends to diminution in the cost price.

Winding the coils upon a tightly compressed bundle of iron gives a practically solid mass without possibility of vibration either in iron or coils. From the type H is thus eliminated any objectionable "humming" or damage to insulation from constant slight motion of the coils. This is a distinct advantage. and still another is the one cylindrical bounding surface between the primary and secondary, doing away with corners or other surfaces inconvenient to insulate. A simple plain cylinder of insulation, composed principally of mica, projects well beyond the winding and separates effectually the primary and secondary windings.

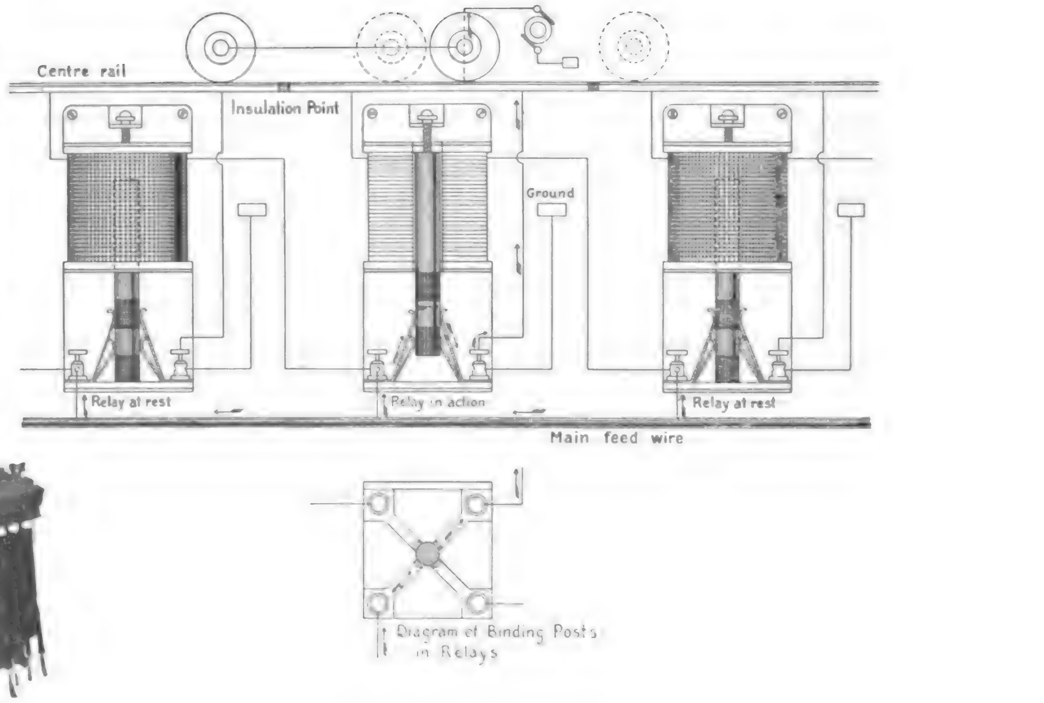
To form as strong a barrier as possible against a high potential on the secondary, a protective device is added to the insulation. This is the so-called "Earth Shield," which is simply a sheet of coppèr placed between the primary and secondary windings and connected to earth. Thus, even should the insulation between primary and secondary become pierced, this grounded shield would prevent any part of the secondary system being at any great difference of potential from the earth, and remove any possibility of danger to life and property due to high potential on the secondary winding.

The usual type of transformer could with difficulty only be provided with this shield while with the type H the addition is both simple and effective. Fig. 2 shows a 10-KW transformer of this type partially completed, the right hand core equipped with its shield and another shield standing in front of it. While the General Electric Company does not provide this shield in standard transformers, it can readily do so when required.

The relative positions of the iron and copper in the design of the type H is reversed when compared with transformers of other makes. In the usual construction, the copper is buried inside the core, and is therefore, in the hottest part of the transformer, sometimes 75 degs. to 100 degs. F. above the temperature of any accessibl. part.

Fig. 3 shows the careful design of the case It is well proportioned; the cover has a deep flange giving a weather-proof joint, the bushings of both primary and secondary leads are of porcelain placed in projecting compartments at the top of the box, which gives protection to the bushing and ensures ample distance between primary and secondary. Four secondary terminals are brought through the bushings. The transformer can thus be used interchangeably for either of the two secondary voltages for which it is wound or on a "three-wire secondary" system. A connecting board placed in the case provides for a similar coupling of the two primary coils in series or multipie.

THIRD-RAIL RELAY SYSTEM.



THIRD-RAIL RELAY SYSTEM.

Many systems for operating electric railways without the objectionable overhead wires have been tried, but thus far, for one reason or another, none have come into popular favor. The latest and one which is claimed to meet all requirements, is illustrated herewith, and known as the "Third Rail Relay System." As the name indicates, the current is supplied through a third rail which is laid in the center of the track in relays of 5 ft.; that is to say, the sections of the middle rail are only 5 ft. long, and are separated by some 4 ins. of insulating material which prevents the current from passing through more than one section at a time. This is claimed as an important factor, doing away with any possible danger to the public when it comes in contact with the rail.

In the center of each relay, midway between the points of insulation, is placed an

iron box containing a solenoid magnet holder. This magnet controls a vertical bar holding it up, or letting it down, as the current is on or off in that section or relay. The feed wire from the power house is attached to one of four terminals on the solenoid holder. The current then passes through the vertical bar to another wire, diagonally opposite, which feeds the middle rail. The current, however, cannot pass through the bar unless the car is on that section, as the bar is partially insulated and remains down with the insulated part against the brushes of the terminals until the car comes along.

The connection between the rail and car is by means of a shoe about 2 ft. long fastened under the center of the car. The shoe passes the insulation point and connects the live section to the next one in front, which up to that time has been dead. The solenoid magnet then holds up the vertical bar, allowing the terminal brush to rest against the uninsulated part until the car has passed to the next section. The raising of the bar in the next section cuts off the current in the preceding relay and that bar drops down again, making that portion dead until another car comes.

It will thus be seen that only the section of rail directly under the car has any current in it, and as each section is only 5 ft. long, the car completely covers it and prevents accidents. The company claims that it is impossible to short-circuit the current and offers a money prize to any one who can do it. Each solenoid holder is grounded separately.

Some of the points of superiority which the company claims for this system are: There is no magnet or storage battery in the car, the current from the power house doing all the work; each section energizes itself as needed and becomes dead as soon as the car has passed, there being no waste of current and none used except immediately under the car; it is practically indestructible, as there is nothing to get out of order, there being no levers, bolts, cranks or springs of any description, and it needs no oiling or cleaning. The system can be put on any surface road without removing a tie; it requires only the digging of a trench, under the center rail, one foot deep and one foot wide. The magnet holder is placed between the ties in an iron box and the magnet portion thoroughly surrounded with insulating material to prevent sweating. The lights in the car never go out when making a crossing or switch, but burn steadily as long as the car is in service.

The above described system is now being exhibited by the Empire Electric & Manufacturing Company, 54 Stone Street, New York.

A NEW SWITCH-BOARD.

The switch-board of the new Commercial Cable Building on Broad Street, New York City, is so elaborate and complete, and its methods of manipulation of the output of the two generators it controls are so original, that it is worthy of special description.

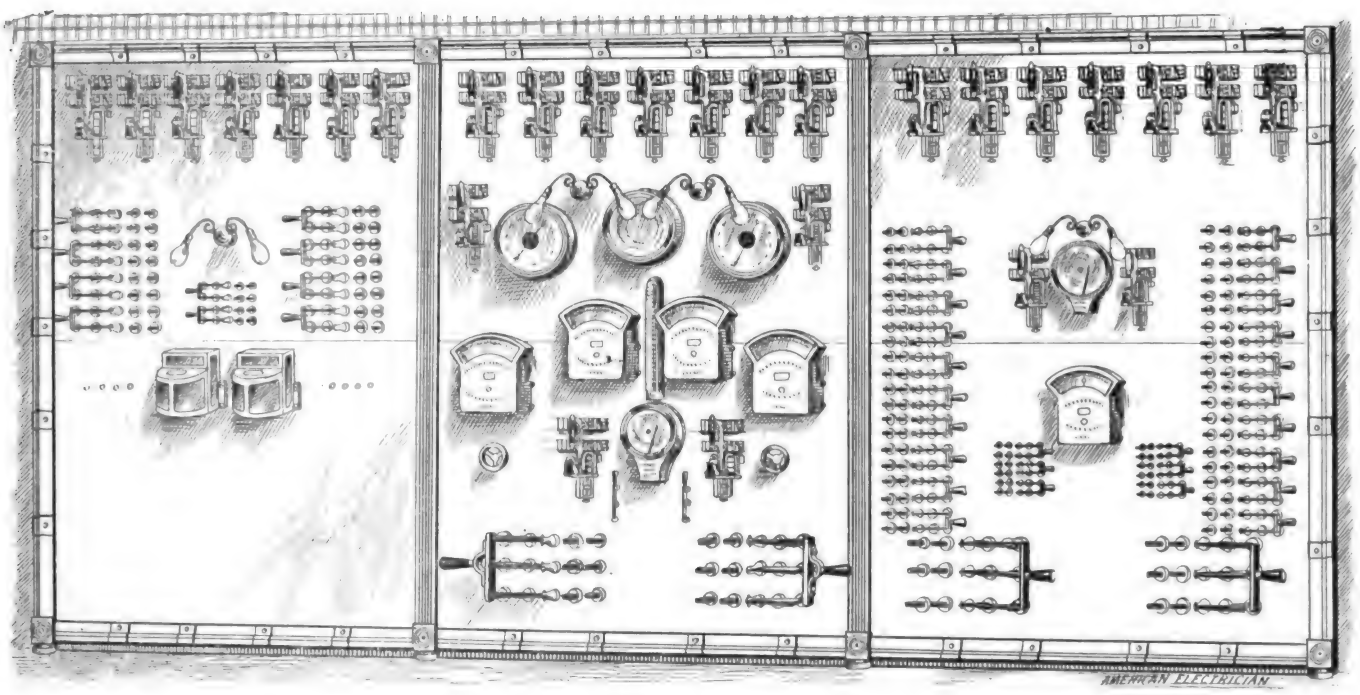
The board is mounted upon polished brass legs and is made of slate, marbleized in imitation of Tennessee marble. There is one large main board and one auxiliary board similar in general construction, but much smaller, which serves to control the Edison service from outside. These boards are set 40 ins. from the wall and are to be surrounded by brass grille work which will shut in the backs. A door between the boards which can be securely locked assures that only the proper parties shall have admission to the rear of the boards. The larger board controls the output of two direct-connected Siemens & Halske generators of 100 KW each.

The voltage of the system is 250 and lamps of corresponding voltage will be used throughout. This makes the plant particularly interesting. There is a system of electric elevators and numerous small powers about the building which must be fed from the generator circuits and therefore it is necessary to devote one generator to power and the other to lighting and run them independently. When the lighting load is small it may be convenient to run only the power generator, and therefore every switch on the board is a double-throw switch, so that the circuits they control may be thrown on to either the power or lighting bus bars at pleasure.

Inasmuch as it may be desirable that the dynamos interchange their functions, the main switches are, therefore, double-throw also, thus enabling either machine to be switched on either set of bars. The copper bus bars at the rear of the board are most massive, being 3 ins. × ½ in. in section. They are mounted upon studs which are integral parts of the switches on the other side of the board, thus avoiding joints. The connections to the circuit-breakers are by flexible leads. The rheostats that control the machine are back of the board, and are operated by a handle on the front.

The instruments on the front of the board are of strikingly high quality. The main switches are of 1000 amperes capacity, and two of the circuit switches are of 600 amperes capacity. There are thirty circuits in all, each of which passes through an I. T. E. circuit-breaker and a double-pole, double-throw switch. There are also two 1000-ampere circuit-breakers, and thus all fuses are eliminated. The measuring instruments consist of two 300-volt, illuminated-dial Weston voltmeters, two 1000-ampere, illuminated-dial Weston ammeters and one Weston ground detector. There are also two Thomson 1200-ampere recording wattmeters, while a Bristol recording voltmeter furnishes daily records of the constancy of electric pressure at the bus bars. A number of steam gauges and a clock are symmetrically placed upon the board, and balance up the other instruments. The board is trimmed with a heavy polished brass moulding.

All of this material, with the exception of the rheostats, circuit breakers, and the measuring instruments, was made at the works of



A NEW SWITCH-BOARD.

the Electrical Engineering & Supply Company, Syracuse, N. Y., and it is but justice to say that but few shops could produce such a large and substantial variety of switch-board material.

The auxiliary switch-board for the Edison system carries two 750-ampere, double-throw switches. There are also two recording watt-wattmeters of appropriate capacity on this smaller board.

A QUARRY ELECTRICAL INSTALLATION.

An interesting electrical installation has recently been made in the quarries and mills of the F. O. Norton Cement Co., at Binnewater, N.Y., situated in the Rosendale cement district, about seven miles from Kingston.

The electric plant consists of a 30-KW alternating-current incandescent dynamo, manufactured by the General Electric Company, as in fact are the lamps and wiring devices of which the plant consists.

There are now installed 103 incandescent lights, lighting the kilns shed, where the calcined product is taken to the crushers, the mills, the packing rooms, the shipping rooms and other departments of the factory.

The quarries are lighted by forty incandescent lamps and fourteen arc lamps. The current is used at a pressure of 300 volts, being reduced by transformers to the necessary voltage for arc and incandescent lamps. Each arc lamp is operated by its individual transformer; in addition, one or two incandescent lamps on flexible cords, protected by wire cages, will be operated from the same transformer where particularly close light is required.

Arc lamps are also connected by flexible cord to the transformers which are placed back of the nearest pillar to the face of the gallery. The lamps are supported from the roof of the gallery by means of rope and pulley and give a most satisfactory general illumination for the whole work. The men have suspended a light for handling the drills and shoveling the broken stone in the loaded cars, etc. Incandescent lights fixed in position are placed at the main platforms, turn-table, etc., while lamps for the purpose of general illumination are also placed at moderate intervals along the galleries now being operated. When the blasts are fired, the lamps are unhooked and taken back behind the pillars.

The circuits are carried into the quarries from the power house a distance of about 400 ft. in one direction and 1500 ft. in the other. They are carried along the galleries fastened to insulators fixed to plugs driven into holes in the roof of the worked-out galleries. From various points main loops are carried to the galleries where the work is going on.

NEW BOOKS.

ELECTRIC TELEGRAPHY. By Edwin J. Houston and A. E. Kennelly. New York: The W. J. Johnston Company. 448 pages, 163 illustrations. Price, $1.

This is the tenth and final volume of the Electro-technical series, and, like its predecessors, is a handsome specimen of the book-maker's art. The subject to which it is devoted is treated popularly but at the same time with due regard for technical correctness. The explanations of the principles of some of the more complex systems of telegraphy are made so simple as to place them easily within the understanding of the average non-technical reader. Submarine telegraphy is very satisfactorily treated, one of the authors being a world-wide authority in this branch.

ELEKTRICITÄTS DIRECT AUS KOHLE. (Electricity Direct From Carbon.) By Etienne de Fodor. Vienna and Leipzig: A. Hartleben's Publishing House. 306 pages, 67 illustrations. Price, 3 marks.

This is a compilation of original articles and abstracts on the subject of electricity direct from carbon, including the substance of almost all the contributions on that subject which have appeared in the technical press during the past five years; and a historical synopsis extending back to the beginning of the century. The author appears to have thought it necessary to include all galvanic batteries containing a carbon electrode, even those in which the energy is evidently derived from the consumption of zinc, such as the Le Clanché and Grenet batteries. It is to be regretted that some of the abstracts are made, not from the original papers, but from other abstracts. The book is a timely and, to those particularly interested in the subject, a very useful compilation.

APPLIED MAGNETISM. By J. A. Kingdon. London: H. Alabaster, Gatehouse & Company. 292 pages, 75 illustrations. Price, $3.

The author intends these pages to explain in a simple manner the modern quantitative applications of magnetism, so as to be intelligible to any student who has grasped the meaning of the volt, the ampere and the ohm, and also to serve as an introduction to the design of dynamos and other electromagnetic apparatus. The first three chapters are on the general principles of magnetism, electromagnetic units and magnetomotive force. The following chapters are principally on the applications of magnetism to practical purposes. Among the subjects thus treated are magnetic tractive force, the dynamo and alternator, magnets and magnetic leakage, commutators and collectors, hysteresis and heating of magnets. Other chapters are on magnetic measurements, polyphased fields, electric motors, qualitative magnetism and the generation of E. M. F.

TRADE PUBLICATIONS.

Automatic Friction Clutches. With this title the Automatic Friction Clutch Company, Erie, Pa., has issued a neat pamphlet fully descriptive of its automatic friction clutch and cut-off coupling. In bringing out the merits of this new type of clutch, the subject of clutches in general is gone into at length, which gives the pamphlet a value beyond that usual with similar publications.

Gauge and Wastage Rod. J. Studebaker, 2700 Emerson Avenue, South Minneapolis, Minn., has issued a pamphlet devoted to an ingenious device for gauging the contents of a barrel. Judging from the many recommendations printed, of which a number are from the managers of electrical plants, this device renders excellent service wherever it is thought desirable to check the invoice quantity of oils and other liquid goods.

X-Ray Apparatus. The Boston Motor Company, 17 Batterymarch, Boston, has issued a new catalogue describing the various apparatus of its manufacture. Among these are a number of X-ray generators—static and Ruhmkorff—fluoroscopes, X-ray photographic plates, etc. Fan motors for battery, alternating and direct current are also well represented. The pamphlet in addition contains several useful tables and other information of value.

Twist Drills. The Morse Twist Drill Company, New Bedford, Mass., in a 64-page octavo catalogue lists several thousand twist-drills, reamers, taps and dies, an illustration of each type also being given. Two pages give valuable information, accompanied by illustrations, on grinding drills, with a table showing the proper speed for drills of different diameters, and for different metals. This information should be indispensable wherever a drill is used.

High-Insulation Line Material. Fred. M. Locke, Victor, N. Y., has issued a new edition of his catalogue of high-insulation line material, to which have been added excellent illustrations, accompanied by detailed descriptions, of the latest types of Locke insulators, designed for the highest voltages that have yet been proposed for commercial work. These insulators are a vast improvement on the oil insulators which have been so largely used in European high-tension work.

Corliss Engines. In a handsome 72-page catalogue the Murray Iron Works, of Burlington, Ia., illustrates in great detail the "Sioux" Corliss engine. All of the various parts are shown in detail, in some instances a half-tone view accompanying a reproduction of a mechanical drawing, thus enabling a most excellent idea to be formed of the actual nature of what is illustrated. The half-tones are unusually well executed as, indeed, are all of the engravings, and the pamphlet is well printed on paper of special quality.

Gas Engines. The Olin Gas Engine Company, Buffalo, N. Y., in several pamphlets recently issued, treats of the merits of the Olin gas and gasoline engine from several points of view. One pamphlet contains a description of the machine, accompanied by excellent illustrations which make its action easily understood. Another contains a brief history of the gas engine, together with many reasons for its use in electric lighting; and in a third are printed many flattering testimonial letters from users of the Olin engine.

Westinghouse Steam Engines. The latest publication of the Westinghouse Machine Company, Pittsburgh, Pa., is well up to the high standard of its predecessors. The subject is the Westinghouse steam engine, and every type is illustrated by extremely well executed half-tone engravings. In addition there are a large number of views of important engine plants installed by the Westinghouse Company, whose value is enhanced to engineers from the information they impart concerning machinery and piping arrangement in general.

Electromagnetic Railway. In a well printed catalogue containing a frontispiece portrait of the inventor, the Leffler electromagnetic railway system is described and many cars shown labeled with the name of the system. The description states that in this system "One member of the motor, viz., the field or armature, is extended along and made part of the roadbed, while the other is on the car." It is singular that at this period of the electrical age a railway system should be seriously put forward whose principle is that of the old Froment engine—obtaining motion by simple magnetic attraction.

Transformers. The latest production of the General Electric Press is an admirable specimen of the printer's art, the design of the cover being particularly handsome. The title of the publication is "Use and Abuse of Transformers," and the text largely consists of technical information of permanent value. A number of curves are included to illustrate efficiencies and various losses, and several tables give transformer data of much interest and value. This handsome pamphlet illustrates the increasing tendency of trade publications to enhance the probability of their preservation by giving the contents a real technical value.

Air-Brakes. One of the handsomest catalogues—if not the handsomest—of the year is that recently issued by the Standard Air-Brake Company, 100 Broadway, New York. In paper, cover, engraving and typography, it ranks as an *edition de luxe*, while from the reading standpoint it is a model of advertising literature, every sentence, phrase and word being directly to the point. All of the various parts of the "Standard" air-brake are illustrated by excellent halftone engravings, which, with the concise accompanying descriptions, enable the reader to appreciate in full the merits of the apparatus. Owing to the great expense of this publication, it is not intended for general circulation, but can be obtained by anyone interested who is in a position to further the cause of air-braking.

Water Wheels. Two recent catalogues which rank as technical treatises have been issued by James Leffel & Company, Springfield, O. One, of 124 pages, is devoted to the turbine, and contains more practical information on that subject than may be found in any professed technical treatise. Besides excellent illustrations and descriptions of scores of different wheels, practical information is given concerning the improvement of water-powers, the construction of pen-stocks, wheel pits and fore-bay racks, on the flow of water in pipes and loss of head—in fact, on every point concerning the hydraulic and constructional questions that come up in connection with turbines. The other pamphlet is on the impulse and reaction wheel for use under large heads. This, like the other pamphlet, is profusely illustrated with excellent cuts, including views of installations.

BUSINESS NEWS.

Mr. L. E. Frorup, general sales agent of the Schiff-Jordan Company, has gone to Europe on busines in the interest of his company.

Mr. Charles Blizard, New York manager of the Electric Storage Battery Company, has removed to new and commodious recently completed offices in the Commercial Cable Building, 20 Broad Street.

Mr. E. J. Wessels, general manager of the Standard Air-Brake Company, sailed for Europe on the steamship "Majestic" on June 2, in the interest of the air-brake business abroad, which has substantially increased from the time he first went over the ground in person.

Motor Switches. The F. & C. motor switches make up a new line of goods which the Electric Appliance Company, of Chicago, has recently added to its already complete and extensive stock. The F. & C. switches are claimed to fill the bill for a low-priced motor switch in capacities of 35 and 65 amperes.

The Keystone Electrical Instrument Company, of Philadelphia, will be located in Parlor E, Cataract House, Niagara Falls, during the National Electric Light Convention. It will have on exhibition there a full line of its instruments and will try to make things pleasant and interesting for such of its friends as call.

A Large Engine Shipment. The St. Louis Iron & Machine Works, St. Louis, Mo., is building for the Consolidated Steel & Wire Company, for its Pittsburg, Pa., plant, a tandem-compound condensing Corliss engine of 1800-HP and a cross compound condensing Corliss engine of 2200-HP capacity. This shipment will weigh 300 tons and will require sixteen cars to transport it.

The Dearborn Electric Company, 330 Dearborn Street, Chicago, has recently placed upon the market a new 100-hour enclosed incandescent arc lamp for use on 100 to 125-volt circuits. Many points of excellence are claimed for this lamp which are not found in other types, one of the principal ones being that of its light weight (11 lbs.) and its simple and easy method of trimming.

The Standard Air-Brake Company closed the month of May by securing an additional order from the colonies for twenty-eight air-brake outfits for electric motor and trail cars, and another order for additional motor car air-brakes. In view of the fact that its air-brakes have been in use in the colonies for nearly three years, this latest order emphasizes the success of the apparatus.

Electric Fans. The fan season may now be said to be fairly opened, and a large business should be done during June and July. The Electric Appliance Company is in the field with a large and complete fan catalogue, showing its full line of alternating and direct-current desk, wall and ceiling fans. This catalogue will be valuable to every purchaser of electric fans of any kind.

The Lakon Company, of Elkhart, Ind., is now nicely located in its new factory and is prepared to fill all orders on account of its increased facilities, with even greater dispatch than heretofore. Mr. O. M. Ash, the electrician of this company, is at present on an extended Western trip. Recent reports from Mr. Ash state that business is brisk and the indications for a good trade in that territory are very flattering.

Police Patrol and Fire Alarm Boxes. The Stromberg-Carlson Telephone Manufacturing Company, Chicago, is just about to issue a new catalogue. This company is just placing before the trade an entirely new system of police patrol and fire alarm telephones, which differs radically from all other systems now in use. The points of superiority claimed for this new system are that it is much simpler and is much more efficient.

Ball Engines. The Hammond Building, of Detroit, Mich., will in the future furnish its own electric lighting. The dynamos were furnished by the General Electric Company and the engines by the Ball Engine Company, Erie, Pa. The Harper Hospital, of Detroit, Mich., has recently put in its own electric plant, consisting of two engines built by the Ball Engine Company, Erie, Pa., direct connected to General Electric Company dynamos.

A Cleveland Repair Shop. The W. H. Elliott Electric Company, Cleveland, O., makes a specialty of repairing dynamos, motors and armatures. Mr. C. I. Cartwright, the head of this concern, reports business very good, having recently booked orders sufficient to keep the company busy for the next two months. Mr. Cartwright claims to be the first to establish an electrical repair shop. The Cleveland Electric Railway Company gives its entire repair work to this company.

Telephones. The Chicago Telephone Supply Company, 118 Quincy Street, Chicago, reports that the demand for its "Boss" long distance telephone is steadily on the increase, and it is highly gratified with the satisfactory reports constantly being received. It further states that the Berliner decision seems not to have checked the activity in independent telephone lines, but the settlement of the question seems rather to have increased the construction of new exchanges.

New Telephone Exchanges. The D. A. Kusel Telephone Manufacturing Company, of St. Louis, is enjoying quite a large business in its line, having recently closed contracts and filled orders for exchanges at Biloxi, Miss., Bunceton, Mo., Sorento, Ill., and Wagoner, I. T. It reports the outlook as being quite bright, as it is not having any trouble in satisfying its customers in regard to the Berliner decision, which is frightening a great many independent telephone companies.

Oil Filters. The Acme Filter Company, 201 Biddle Street, St. Louis, reports business greatly improved during the past month, its sales averaging more than two filters per day in that time. In a list of recent purchasers we note a number of central and power stations and such firms of national reputation as the Vacuum Oil Company (five filters), Manning, Maxwell & Moore (two filters), Illinois Steel Company (two filters) and a number of other concerns whose orders are not given ii discriminately.

The Adams-Bagnall Electric Company has recently closed a deal by which it will confine itself exclusively to the manufacture of arc lamps, having sold its incandescent business and factory, its late manager, Mr. Rogers, and Mr. Arnold, of its engineering corps, having gone with the incandescent business. The Adams-Bagnall Company has moved into much larger quarters, which gives it nearly double its previous capacity and the manufacturing facilities which its previous experience showed it would be desirable.

Onondaga Generators. The Onondaga dynamo of Syracuse, N. Y., is meeting much success with its direct-connected multipolar machines, having recently installed a 15-KW direct-connected plant in the Lackawanna Brewing Company's brewery at Scranton, Pa; a 25-KW, direct-connected unit at Good Counsel Farm, White Plains, N. Y., and a 75-KW, direct-connected unit in the shoe store of S. Rosenbloom Sons, of Syracuse, N. Y. The Onondaga multipolar generator has become widely known for its high efficiency and its sale is rapidly extending.

Electric Lighting Engines. The Chandler & Taylor Company, Indianapolis, Ind, reports that it has recently equipped the Forest Park lighting station, of St. Louis, with one of its double throttling engines for operating a scenic railway, and has also installed one of its latest designs of self-contained automatic cut-off engines for operating the electric light plant. Steam for these engines is furnished by a battery of boilers, manufactured and installed by the same company. This plant is considered a very efficient one, and is giving great satisfaction.

The Chicago Insulated Wire Company, Chicago, has just removed from 153 Lake Street, to 152-54 Lake Street. The new offices are much more commodious and convenient than the old one, the company's facilities for handling its rapidly increasing business being greatly improved. Starting in 1893 under the present firm's management, this business has been steadily and solidly built up until at present the Chicago Insulated Wire Company is well and thoroughly known throughout the central and western territory for its promptness, energy and reliability.

Switch-board Instruments. Among the switchboard instruments that have become widely and favorably known to the electrical trade are those built by the S. E. I. Company, Syracuse, N. Y. This company informs us that its trade in these goods has increased to ten times the volume of last year, and that while the price remains the same the quality has been improved, no expense having been spared in perfecting the instrument. As a guarantee is given with every instrument, the high claims made by the manufacturer as to superior merit are not idle ones.

Ball & Wood Engine Company. The increasing inquiry and orders for its engines have led the Ball & Wood Company to add to its selling department by bringing Mr. Greenwood from its works, of which he has had charge for the past year and a half, to the New York office to assist Mr. Vincent. Mr. John D. Bird, formerly superintendent of the George H. Corliss Steam Engine Works, of Providence, R. I., has resigned his position there to accept a similar one with this company and he will in future be the superintendent and in charge of the Ball & Wood Company's plant at Elizabeth.

New Quarters of Baker & Company. Among the business changes that have been made in the electrical field and its allied interests, we observe that Messrs. Baker & Company, the platinum refiners, have completely renovated the offices they have occupied for a number of years at 121 Liberty Street, taking the entire front of the building, which has been remodeled and greatly improved. Messrs. Baker & Company were particularly fortunate in having as landlords John A. Roebling's Sons Company, who have spared no expense in co-operating with Baker & Company in making these improvements.

Paper Pulleys. The Rockwood Manufacturing Company, of Indianapolis, Ind., is having much success introducing its paper pulleys for electrical work. Among recent sales are twenty-eight pulleys to the General Electric Company, and twenty-eight to the Siemens-Halske Company; among other well-known firms to whom recent shipments have been made are the Link Belt Machinery Company, the Royal Electric Company, the Bullock Electric Company, the Billings & Spencer Company, the Western Electric Company and the Ridgeway Dynamo & Engine Company. Central stations are also well represented on the same list.

Gas Engine Sparking Outfit. The Franklin Electric & Manufacturing Company, Miamisburg, O., is placing on the market a dynamo specially designed for furnishing current for operating the electric-spark igniter of gas engines. One of the special features of the machine is the brush-holders, which hold the brushes at the proper point of contact on the commutator at all times, thus doing away with destructive sparking. A starting cabinet, forming part of the outfit, contains the spark coil, switch and dry storage cells for starting up, used in starting up the dynamo, the latter being belted to the gas engine, and switched in as soon as the engine has gotten up to speed.

Mr. C. L. Hartsfeld, the contracting agent for the National Ore & Reduction Company, 415 Locust Street, St. Louis, has just returned from a ninety-day trip in California and Mexico. During this time Mr. Hartsfeld has traveled by train, stage, horse and burro-back over 8000 miles and has erected for his company furnaces at the following places: At Ore-Grande, Daggett, and Silverado, Cal., furnaces of 20-ton capacity and at Visalia, Cal., one of 5-ton capacity. In Mexico, one of 5 tons at O. J. O. Caliente and one of 20 tons at Chichihauhau. Mr. Hartsfeld states that indications for future business in that territory are very bright. The Mexican agent for this company is Mr. W. H. Brown, of Chichihauhau, Mex.

The Eagle Electric Works, formerly the Eagle Electric & Manufacturing Company, of Peoria, Ill., have removed to Washington, Ill., where they have equipped an entirely new factory for the purpose of manufacturing dynamos of from 10 to 200 HP., and a line of multipolar machines of from 50 to 200 HP. In addition, they will manufacture a line of alternating machines of from 500 to 3000-light capacity and a full line of transformers. This company is also in position to furnish estimates for complete installations for central and isolated stations. The incorporators of the company are Frank A. Thone, president, Henry Oelkins, vice-president, and Peter J. Bourscheidt, treasurer, all of Peoria. The company's office is at 124 S. Jefferson Avenue, Peoria.

Water by Electricity. The Boardman River Electric Light & Power Company, of Traverse City, Mich., has been investigating the question of pumping water by electric power instead of steam, and will make an application to the City Council for the privilege of laying water mains through the streets for the purpose of supplying the people with water. A local newspaper states that the Gould pump, which is designed to run by electric power, has been selected

for the work, and adds that the company stands ready to bring an expert electrician, and also an expert pump man, to lay the matter before the Council without expense to the city, to demonstrate what can be done and to enter into bonds guaranteeing satisfactory results, should a franchise be granted.

A Means to Economy. It is well known that the best of people make mistakes. For this reason a man counts carefully any money which he may receive in the course of business. Why is not the same principle applied in the purchase of all kinds of goods? No doubt it is to a great extent, but there is one kind of goods to which, from inconvenience in measuring, this principle is not often applied. We refer to oils, etc., in barrels. More money is lost in buying such goods than in many other kinds. Nearly every barrel, upon careful measurement, will fall short a few gallons. How can the shortage be detected without emptying out the contents? J. Studebaker, 2700 Emerson Avenue, South Minneapolis, Minn., manufactures an ingenious contrivance, which enables this to be done.

The C & C Electric Company, 143 Liberty Street, New York, has recently concluded arrangements with Messrs. Sargent & Lundy, of Nos. 13 and 15 Monadnock Block, Chicago, Ill., whereby this firm, on and after Aug. 1, will act as its selling agents for Chicago and the Western States. During the interim, Mr. F. D. Sweeten, who has long been the manager of the C & C Company's Philadelphia office, will look after the company's interest in the territory above mentioned. The company's office is now at 934 Monadnock Building, where Mr. Sweeten can be found, and where business will be transacted until the change alluded to above shall go into effect. Mr. Martin J. Insull, of Messrs. Sargent & Lundy, will take special charge of the interests of the C & C Electric Company.

The Ward Leonard Electric Company, Hoboken, N. J., lost its factory by fire on the night of May 20, and within 48 hours had started operation again in another building. While the fire was in progress orders were placed for tools and supplies required for its new plant, which a week later was running with full force night and day. Fortunately for the company, its works were running night and day at the time of the fire. The fire broke out at about 8 o'clock at night and the working force was utilized in saving the books, records, data, drawings, and other important records of the company, all of which were saved. The preservation of these records and the good fortune of the company in securing immediately a plant which it could begin work in at once, has enabled it to continue business without any embarrassment to its customers.

Armorite. The Armorite Interior Conduit Company, Detroit, Mich., has found it necessary on account of a largely increased business to remove its factory and offices to Pittsburgh, Pa., where it may be found in commodious quarters at the corner of Second Avenue and Brady Street. It has greatly increased its facilities for manufacturing and is now able to supply armorite conduit in any kind and style and in any quantities. This company has furnished the conduit work for some of the largest buildings in the United States, among the latest of which is the new Girard Building, Philadelphia, claimed to be the finest office building in the world. The material for this building was sold by its Philadelphia agents, Valle Bros. & Company, and is being put in by C. C. Clark & Company, under the supervision of Lewis Rodman Schultz, electrical engineer.

Snap Switches. The O. S. Platt Manufacturing Company, of Bridgeport, Conn., has added to its enviable reputation by the production of a new push-button switch which unites in the highest degree strength, durability and simplicity. After months of experimental testing of the most critical nature, it has been placed before the public as a switch which embodies all of the essential features sought after, but never before attained. Its regular New England snap switches are to-day considered standard by all the foremost dealers, scores of these all over these United States and foreign countries inquiring for and placing orders for the same with the Platt Company, thus furnishing pretty good evidence that there is merit back of its product. After seeing the benefits that are derived from the strong and durable mechanism of its goods, the public begins to realize that an article like an electric switch that can hold its own, and constantly forge ahead for nearly half a score of years, is something worth while to look into, and give a trial.

Water Power Governors. The new relay returning governor just perfected by the Replogle Governor Works, Akron, O., is claimed by the makers to have demonstrated that it ranks first among water power governors, records recently made in the works of the Jos. Bancroft & Sons Company, Rockford (near Wilmington), Del., having shown that these machines have attained the highest degree of efficiency in this kind of work. The governors above mentioned are regulating wheels for cotton mills, and also for electric light and power for the city of Wilmington. They were chosen after a thorough investigation of the various appliances for this class of governing. The manufacturers of this governor are just completing governors of the same type for two large electric railway and power plants in Canada. Two more of these governors will be shipped this month to a large long-distance transmission plant in the South. Also two equipments go to the far West. This latest development by the above manufacturers will merit careful consideration from prospective purchasers of governors.

Tempered Copper for Electrical Purposes. One of the greatest difficulties which the dynamo or motor builder has to overcome, is the selection of pure, evenly tempered copper, as the life of the machine depends upon this fact more than upon any other. The fact that the Miamisburg Electric Company, Miamisburg, O., has for a number of years been furnishing the copper used by the largest electrical manufacturers in the country is a guarantee that its product meets all the requirements necessary. It uses nothing but the best electrolytic ingot copper, free from alloy, as it is well known that the least amount of alloy reduces the electrical conductivity and hence impairs its usefulness. By its process of manufacture it produces a dense, hard segment, free from crystals and pores, which will take a high polish and hence prevent the commutator from sparking. On the other hand, a crystallized porous segment produces a rough, uneven and sparking commutator, which will not only rapidly disintegrate, but soon wear out the brushes. It has taken the company a long time to perfect its process of manufacture and its reputation and success are well merited.

Electric Light Engines. The J. B. Allfree Manufacturing Company, of Indianapolis, Ind., is just installing an engine for the Eagle Electric Works, Peoria, Ill. This engine is one of the center-crank, tandem-compound, condensing, direct-connected to the Eagle Electric Works design of dynamo. In addition to this the same company is installing two 15×14 engines direct-connected to 80-KW. Siemens & Halske generators for the new Metropolis Theatre in Harlem, New York City; an 11×12 engine direct-connected to a 40-KW. Commercial generator for Mr. George G. Fisher, Lowell Ind. An 8×1, engine direct-connected to a 15-KW Jenney generator for the Indianapolis Abbatoir Company, Indianapolis; a 13×12 engine for the electric light plant of the American Tin Plate Company, Elwood, Ind. The company has also engineers in Saltillo, Mexico, at the present time installing two compound condensing plants. An engine is now also being installed at Seymour, Tex., of the compound condensing type; one has been shipped to the Templeton Milling Company, Templeton, Cal., and an 8×10 center crank engine is being installed for the Jersey Packing Company, Hamilton, O.

Speed-Reducing Device for Electric Motor Drive.—The Northern Electrical Manufacturing Company, Madison, Wis., is just putting upon the market a novel plan by which it uses a standard motor in its various sizes while at the same time imparting to driven machines any required slow speed. This is accomplished by the use of its patented invertible bonnet and back-gear device. No outboard bearings are used and the construction is such that there is no possibility of the mechanism getting out of alignment. All the bearings are self-oiling, and the entire mechanism may be run without using any floor space. All of the Northern motors and their various equipments are so built as to run inverted and attached to the ceiling or half inverted and fastened to side wall or post without so much as removing one bolt. All its standard motors are also furnished with tight-fitting portable covers for keeping out dripping of slush from floors above, or dust and dirt. These are immediately attachable to its regular standard bonnets, so that they may be used or not, at the will of the operator. These motors are especially well adapted to factories where there is much dirt and moisture, and to mines and foundries.

Mr. C. H. Wilmerding has severed his connection with the Chicago Edison Company and opened an office in Chicago as designing, constructing, supervising and consulting engineer, more particularly with reference to the planning, remodeling and complete installation of central-station and isolated electric lighting, railway and transmission plants, and the underground distribution of electric currents; embracing also the supervision, in an advisory capacity, of the operating of existing plants with a view to improved economy and greater efficiency. Mr. Wilderming's experience in these branches as general manager for five years of the Chicago Arc Light & Power Company, general superintendent for the past four years of the Chicago Edison Company, and president for the past eight or nine years of the Chicago Sectional Electric Underground Company, and in various civil, mechanical and electric engineering undertakings prior to his associ with these companies, warrants the assuran any work entrusted to him will be exec proper and satisfactory manner, with a f edge of the latest and most approved meth appliances, and the advantage of a daily int with their good points and their faults.

A. L. Ide & Sons, of Springfield, Ill., hav cently shipped to Yokohama, Japan, on the ord of their export agent, Mr. Fred W. Horne, 199 Chambers Street, New York City, one 7×10 single-expansion Ideal engine; one $10 \times 16 \times 12$ in. tandem compound and one 9×10 direct-connected engines all for the Japanese Government. Since this shipment the Ide Company has received a second order for the same size compound engine for the same place. Regarding the home trade the Ide Company states that it has about completed the installation of the three $15 \times 15\frac{1}{2}$, single expansion engines for "The Fair" Chicago. These engines are of a special side-crank, self-oiling pattern and are direct-connected to 100 KW. Westinghouse generators. This company has also just placed for the Koken Iron Works, of St. Louis, one 13×12, 100-HP Ideal engine direct connected to a 500-KW National machine. This unit is to be used for driving various machines by independent motors. The United States Government has also contracted with the Ide Company for four 500-HP tandem compound engines to be direct-connected to centrifugal pumps for dredges on the Mississippi River. In addition the Ide Company was awarded the contract for the lighting equipment of each dredge.

Ball Engines. The Ball Engine Company, Erie, Pa., reports the following recent shipments of engines for electrical purposes: Vulcan Coal Company, Treveskyn, Pa., one 225-HP engine, direct-connected to generator; Queen City Electric Light & Power Company, Clarksville, Tenn., 125-HP engine; Langhorne Electric Light & Power Company, Langhorne, Pa., third order, 200-HP engine; Maxwell House, Nashville, Tenn., third order, 125-HP, direct-connected to dynamo; Rockville Water Works, Rockville, Md., 80-HP engine; Wilmington Gas Light Company, Wilmington, N. C., third order, 300-HP, cross compound engine: Pennsylvania Tube Works, Pittsburgh, Pa., 60-HP engine; Seaboard Air Line, Portsmouth, Va., 70-HP, direct-connected to dynamo; Apollo Iron & Steel Works, Apollo, Pa., fourth order, 150-HP, vertical, cross compound, direct-connected to alternator; Kirk's Soap Factory, Chicago, Ill., 50 HP engine, direct-connected to dynamo; Lexington Hotel, Richmond, Va., 40-HP engine; Congo Mining Company, Congo, O., 175-HP engine; Wainwright Brewing Company, Pittsburgh, Pa., 80-HP engine, direct-connected to dynamo; Fox Pressed Steel Company, Pittsburgh, Pa., 100-HP engine, direct-connected to dynamo; F. O. Norton Cement Company, Binnewater, N. Y., 60-HP engine; Lakewood Hotel & Land Company, Lakewood, N. Y., 165-HP, tandem, compound engine.

B. & O. IMPROVEMENTS.

Some important improvements are being made on the Pittsburgh Division of the B. & O. About 15 miles of second track are being laid, and at Kelly's Cut, near Cumberland, the line is being extensively changed. The work includes a 530-ft. tunnel, three bridges and a mile of new track. Several curves will be eliminated and a treacherous mountain side avoided. The change will cost about $100,000 and will be completed late in the fall.

American Electrician.

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THE ELECTRIC FOUNTAIN AT WILLOW GROVE, PHILADELPHIA.

BY THORNTON B. RENWELL.

OF the outdoor attractions in the vicinity of Philadelphia, one of the most popular and successful is Willow Grove and its electric fountain, the property of the Union Traction Company of that city. On ordinary weekdays last summer the park was visited by from 5000 to 10,000 people, and on Sundays, holidays and special occasions this number has been tripled or quadrupled.

Willow Grove embraces 105 acres of land, lying about 15 miles north of Philadelphia. Owing to the excellent service of the Union Traction Company and the Philadelphia & Reading Railway, access to the park is made so easy and pleasant that the distance, far from being a disadvantage, adds the pleasure of an enjoyable trip. The fountain is situated in the middle of an artificial lake, circular in shape, about 250 ft. in diameter, with its banks and the encircling walk lighted by 300 100-volt incandescent lamps; these are arranged in clusters of five, enclosed in glass globes mounted on sixty 8-ft. poles. The fountain is built in two basins, one over the other. The lower and larger stands 3 ft. above the level of the lake and is 50 ft. across; it is shaped like a square, with curved corners, surrounded by a low wall surmounted by eight urns. The upper basin is 5 ft. above the lower, measures 23½ ft. across and is somewhat octagonal in shape; its rim is also embellished by eight urns.

The fountain is in operation for one hour in the afternoon and for a quarter of an hour three times in the evening. So far, at least 30 variations can be obtained by combining different jets and nozzles, and this number will be further increased in the near future by the addition of another nozzle, the piping for which is in its position and ready for use. With the help of the electric lights and color screens, there is hardly any limit to the variety and change of the display, as the same water formations can be shown in different hues. This fountain, together with one at Pittsburgh and another in course of erection at Brooklyn, was designed by Mr. F. W. Darlington, of Philadelphia, under whose supervision the power houses and road work of the Philadelphia Traction Company, were installed. The electric work on it was done by Mr. Elias Nusbaum of Philadelphia, and the piping and hydraulic system by Mr. Benj. F. Shaw, of Wilmington, Del.

The pavilion on the bank of the lake (shown in Fig. 4) covers the pumping and other moving hydraulic machinery. The pump room, as it is called, is circular in shape (Fig. 6), being 25 ft. in diameter by 15 ft. height of ceiling, and contains two electrically-driven pumps; one of these supplies a stand-pipe that furnishes water for the park in general, and the other and larger supplies the fountain itself, though it can be thrown into the stand-pipe service when needed. The fountain pump is a 9 × 12 Gould triplex, with a capacity of about 1000 gals. per minute and driven by two 75-HP G. E. railway motors, one on each side, coupled to a main shaft by plate couplings; the shaft through a double reduction engages the large gears on the pump shaft.

FIG. 1.—"SHEAF OF WHEAT."

FIG. 2.—VIEW WITH WHITE EXPOSED ON COLOR SCREEN.

NIGHT VIEWS OF FOUNTAIN.

An average pressure of about 40 lbs. is maintained on the fountain, the actual pressure varying from less than 30 to 70 or more; in fact it can be raised to 100 lbs. Small changes of pressure do not make a noticeable difference in the appearance of the fountain, and large ones are compensated for by an increase of speed, the motors being regulated by a series-parallel controller worked by hand.

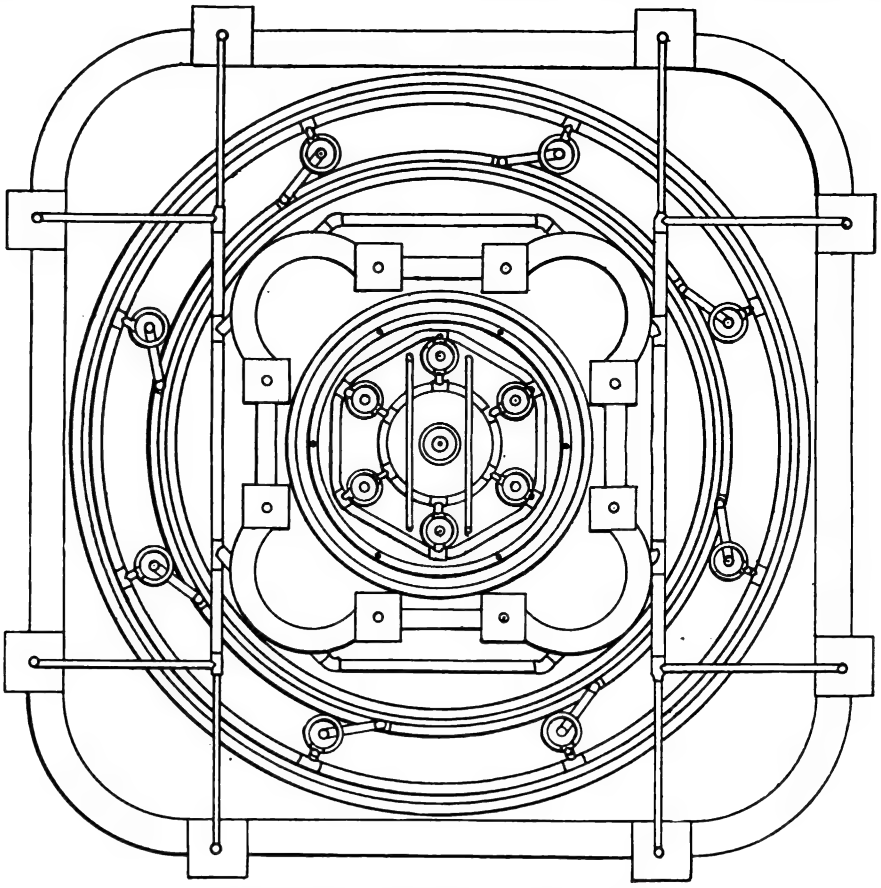


FIG. 3.—PLAN OF FOUNTAIN, SHOWING PIPING.

On the side of the pump room, facing the fountain, an iron floor is raised about 7½ ft. and three windows are cut in the wall to furnish a room for operating the water valves and watching the workings of the fountain (Fig. 7). A large speaking tube is used for signaling to the electrician under the fountain what colors are wanted.

The twelve nozzles that constitute the fountain are operated from this room by two rows of twelve levers each, arranged with an aisle between them. The levers are 3½ ft. long and are connected to quick-opening gate valves in the pipes below, which lead off to the fountain. Each lever works over a quadrant with fourteen notches, representing different heads of water that can be admitted to that pipe; this is very important, as the nature of some designs can be completely changed by the pressure, as for instance, one formation called the "Sheaf of Wheat," which is changed to a "Vase" under greater pressure. The two rows of levers make up two complete sets of valves for operating the fountain, the object being to enable the operator to arrange one set to any design while the other is in service; two valves are placed in the supply pipes for these two systems, connected by chain belts —one straight and the other twisted—to a hand wheel in the operating room (Fig. 7), and by turning this the new formation is gradually worked into the place of the old.

Switches for the light circuits connected with the fountain and lake are mounted on a marble slab over the row of levers on the left of the room; these lights are extinguished while the fountain is playing. The controller for the pump is also in this room.

The fountain is located about the middle of the lake, being a little nearer to the shore where the pump room is. The lower basin contains five of the twelve nozzles that constitute the fountain. The outermost jet consists of a ring of 6-in. pipe, with 100 ⅛-in.-brass tips screwed in it at equal intervals, their outlets inclining to the middle of the fountain. Next, are eight rings that form what is called the "Sheaves of Wheat;" these are circles of pipe with sixty-eight ⅛-in. tips each; the tips have a spiral twist so that the jets of water issuing from them will cross each other at the proper height

FIG. 4.—DAY VIEW OF FOUNTAIN.

FIG. 5.—NIGHT VIEW, SHOWING FAN.

and fall outwards, which produces the appearance of a sheaf of wheat. These circles are placed over the light portals, as shown in Fig. 9. One ¼-in. nozzle is placed in the center of each of these small rings, inclining considerably towards the middle of the fountain; the next pipe is as yet blanked off.

The innermost pipe shown supplies the eight urns mounted on the outer wall and the eight on the top basin, which are not illuminated, being used for day exhibitions; they are fitted with rotating nozzles. The top basin has the remaining seven nozzles. The outermost is a circle of 6-in. pipe, with fifty-eight ¼-in. tips pointing vertically; they cannot very well be illuminated, as their streams are directed straight up, and do not cross the path of the arc lights, and are used principally for day displays. Next is another circle of 6-in. pipe, with eight 1¼-in. nozzles. Inside of this are six small circles, with eleven ¼-in. vertical jet tips in each, and, like the "Sheaf of Wheat," encircle the light ports; six ⅝-in. nozzles are placed in the center of these, all directed vertically. Next are two semi-circles of pipe, parallel with each other, and having eighty-eight ⅛-in. tips, inclining to the center, screwed in their circumferences, furnishing what is called "The Fan." In the center of all is another small ring of pipe with eleven ¼-in. vertical tips, with a 1½-in. vertical nozzle in the center.

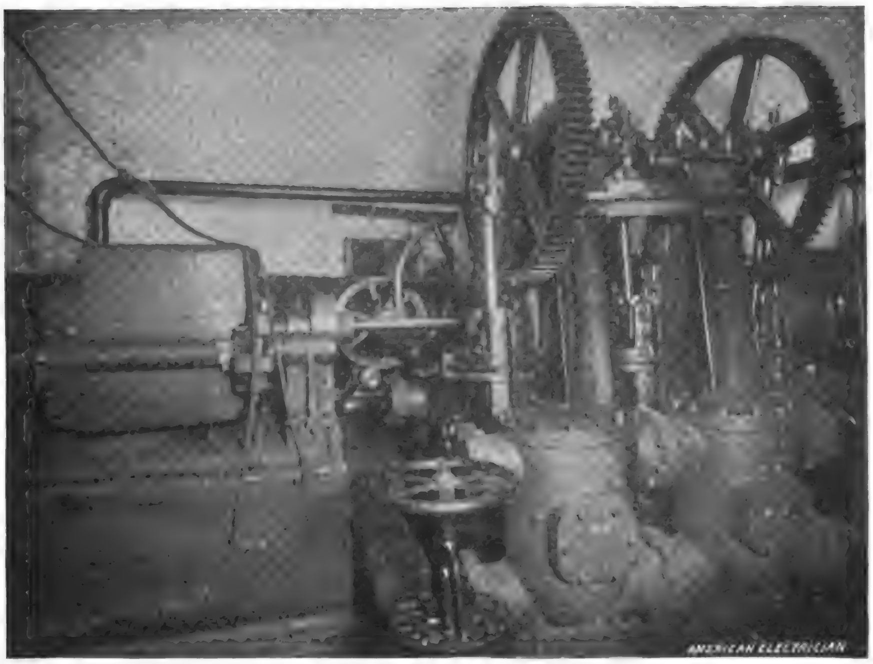


FIG. 6.—INTERIOR OF PUMP ROOM.

Each one of the above twelve formations is connected by a separate line of pipe to a separate valve and can be worked individually or in unison with the others. It may be easily seen now that by combining the above pipes, a great variety of formations is possible. For instance, a pyramid is made by throwing the outer ring on the bottom into service under full head; this can be varied by diminishing the head of the outer ring and opening the outer and center rings of the top basin, which gives the pyramid three steps. The "Fan" effect is very handsome; the separate jets unite into a broad sheet about 80 ft. across, which, by the way, the electrician means to turn to a rather novel use by throwing stereopticon views on it between the regular performances.

The "Sheaf of Wheat" is one of the handsomest formations this fountain is capable of producing. The shape is very true to life (Fig. 1) and the resemblance is heightened by displaying it in amber. While only six of the formations are actually over the light, three of the remaining five are so near that they get the benefit of it.

The illumination is effected by fifteen 8000-CP, 40-ampere Rushmore focussing lamps, using ¾-in. carbons, with conical or hood-shaped reflectors below the arc and extending upwards enough to concentrate all the light on the color screens directly over them. These reflectors increase the intensity of the light to about 12,000 CP. The lamps are supposed to burn (with a resistance) in parallel on a 100-volt circuit, and so are arranged in three circuits on the 500-volt circuit, the resistance boxes being mounted on a board separate from the lamps. The apartment that contains the illuminating apparatus is a room under the fountain 44 ft. from wall to wall, and has the shape of the lower basin, being square with the corners rounded. Under the lower basin the ceiling is 8 ft. high and 13 ft. under the upper. The walls are of stone and brickwork 30 ins. thick; the flooring is of concrete heavily cemented over, with stone foundations for the columns that support the ceiling and superstructure. This room is shown in Fig. 7.

To protect the interior of the fountain from water, cast iron casings shaped like truncated cones, with plate-glass tops, are fitted into the cement work of the basins; these portals are 22 ins. in diameter at the top and 26 ins. high; eight are in the lower basin, inclining toward the common center, and seven vertical ones in the upper.

The lamps rest on iron stands under these casings (Fig. 9). The outside nozzles are about 7 ft. above the lamps and the middle about 12 ft. Between the lamps and casing five disks are set, screwed to vertical shafts that have bearings on the ceiling and floor; these disks are 5 ft. in diameter and have red, green, purple and amber circles of glass and a round hole for white. The center and outer disks are hung, 10 ft. and 5 ft. respectively, above the arc lamps, and the glass screens have a wire mesh under them to prevent them from falling apart from the effect of the heat (Fig. 9). These disks are operated by chain belts, sprocket wheels being secured by a clutch arrangement to the shaft near the ceiling; wire ropes running over pulleys connect the fifteen separate belts to as many hand wheels that are mounted on a rack at the entrance to the room. The wheels have five handles, each handle painted to correspond with a color on the disks and each with a catch that drops in a notch in the shaft on which the wheel rotates, when that color is directly in line with the lamp. A hand wheel on the extreme left of the rack couples

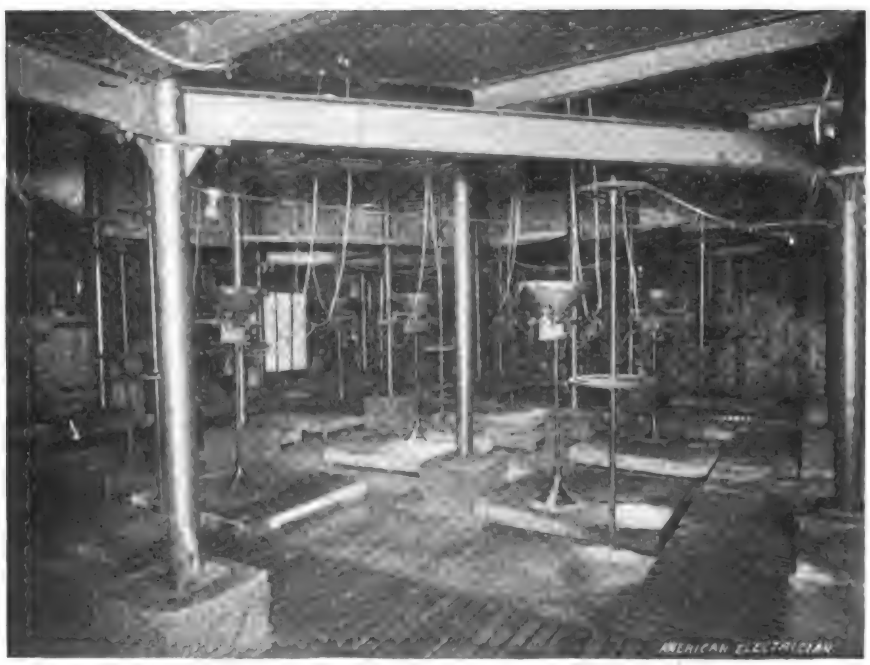


FIG. 7.—INTERIOR OF FOUNTAIN BASEMENT.

the eight disks of the lower basin together, so they may be moved as one when desired. On the right, a hand wheel is similarly arranged to control the seven center disks. A wheel in the center of this rack can couple all fifteen together; this makes it possible to work the fifteen slides at once, the two sections, or any portion of them separately, or each one individually. As each handle on each wheel has a catch, the five colors can be exhibited at once, or they can be divided into numberless combinations. Fig. 10 shows the wheel rack.

In case of a belt breaking or other accident to the controlling machinery, the color slides can be worked by a hand wheel which is secured to the shaft a few feet from the floor. The sprocket wheel has a clutch so that it can be disengaged from the shaft, as shown in Fig. 9.

The fountain basement is connected with the pump room by a duct 3½ ft. wide by 5 ft. high and 90 ft. long. The electric light cables run through this passage. A walk of wood mounted on porcelain knobs is laid on the floor of the duct and around the lamps in the fountain basement; as more or less water finds its way in there, 500 volts would be very uncomfortable if a man were not well insulated from a ground. The duct and basement are lighted by 16-CP incandescent lamps run along the ceiling.

As this installation feeds from a trolley system with the usual grounded return, the arc and incandescent lamps are practically on one wire; that is, the positive wires are of the best make obtainable and are run with care, while a bare trolley wire running along the floor gathers the returns.

Aside from the fountain, the park is of much electrical interest. Electricity is the almost universal motive power, the "Shoot the Chutes," "Scenic Railway," "Carrousel," pumps, elevators, everything, with the exception of an ice machine in the casino, deriving its power and light from electricity. Following is a summary of electrical machinery, lamps, etc., comprised in this installation:

226 HP in motors; 168 HP in arc lamps (80-HP of this is used by fountain lamps); 307 HP in incandescent lamps.

110 2000-CP arc lamps are used for illuminating the grounds, divided into eleven circuits, burning ten in series on the 500-volt current; ten of these circuits are mounted in clusters of five lamps, each with white reflectors on iron towers; the lamps in the remaining circuit are strung singly on poles. 1237 110-volt incandescent lamps on three-wire system are used for lighting the interior of buildings; 3365 100-volt incandescent lamps, five in series, are on 500-volt circuits, making in all 4602 incandescent lamps. The 500-volt current is cut down through motor generators to 110 volts. Two generators are coupled in series to obtain 220 volts for the three-wire circuits.

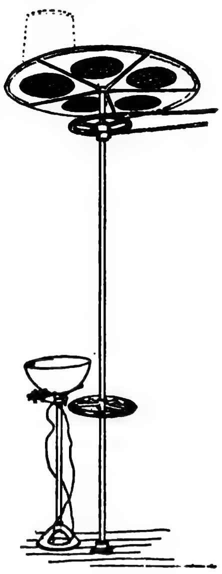


FIG. 9.—COLOR SCREENS AND ARC LAMP.

In the park itself, the wires are all underground, the lead-covered cables of the Safety Insulated Wire & Cable Company being used. These are run in conduits of the Wyckoff type, consisting of creosoted wood with 3 in. holes.

The power house is situated on the outskirts of the park. It consists of 9 return tubular boilers and 5 electrical units, 2 of which are directly connected to and the remaining 3 belted from individual engines. All water is supplied from an artesian well 862 ft. deep. Besides furnishing the park with light and power, this station feeds the end of a long street railway line.

The writer takes this opportunity to thank Mr. W. S. Twining, chief engineer, of the Union Traction Company; Mr. F. W. Darlington, the designer of the fountain: Mr. G. W. Simpson, the electrician of the park, and his assistant Mr. F. W. Leland, for courtesies received from them in the preparation of this article.

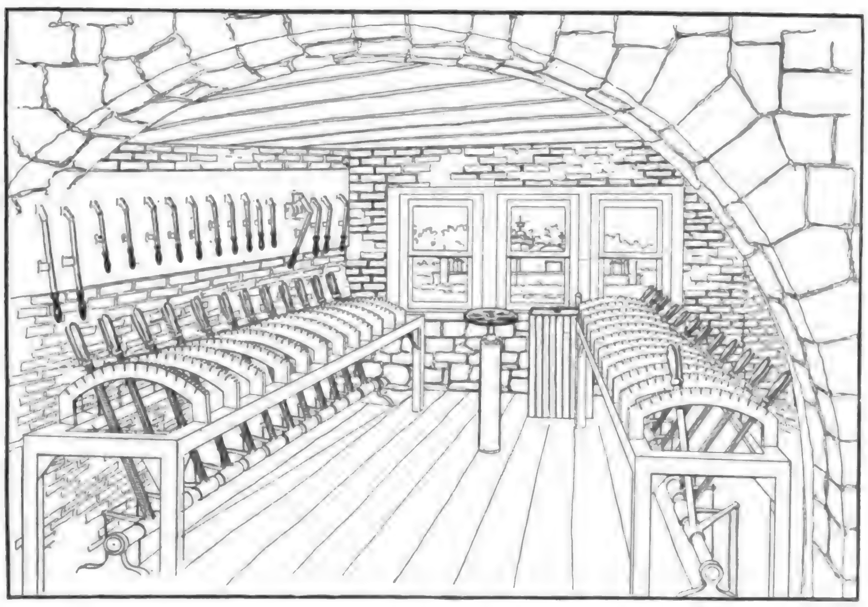


FIG. 8.—OPERATING ROOM.

Preservation of Meat By Electricity.

A process of preserving meat by electricity, says the London *Electrical Review*, has been invented by a Mr. Pinto, of Rio Janeiro. In the ordinary process of pickling

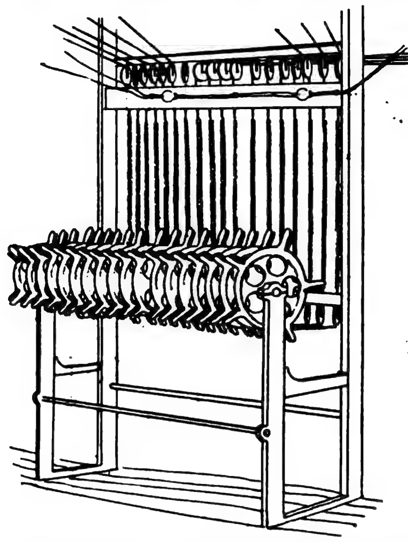


FIG. 10.—WHEEL RACK FOR OPERATING COLOR SCREENS.

meat, it must be left for a considerable time in the pickling solution, to give the pickle sufficient time to penetrate to the interior of the mass. It is this process of saturation which Pinto has succeeded in accelerating by means of the electric current. The experiments of Dr. Gärtner have shown that substances in solution can, when ordinary methods fail, be forced through porous bodies, and even through the skins of animals, by the electrolytic action of the electric current. In Pinto's process the meat is placed in a bath of brine, and a current of about 100 amperes sent through by an E. M. F. of 8 volts; 3 litres of brine are used for each kilogramme of meat. Electrodes of platinum must be used to prevent the possibility of poisonous salts getting into the bath. The electric pickling process takes from 10 to 20 hours. This process is evidently much simpler and more effective than other processes of rapid pickling, such as the injection of brine by syringes, and deserves the attention of all who are interested in preservation of food stuffs.

The Broomhill Plant.

Our English contemporary, *Electricity*, in an editorial note referring to the description of the Broomhill plant which appeared in the May issue of the AMERICAN ELECTRICIAN, says that to the writer the article is strangely reminiscent of old times, bringing up recollections dating to 1874. "It was my lot to be trained in the factory where Sir David had many of his devices manufactured, and to see the illustrations and drawings of the switches, etc., which were first a wonder and then a perplexity, and lastly, I regret to say, a nuisance to me; and I think of the years which have rolled by since then, of the changes time has wrought, and also of the progress electrical engineering has made."

EFFICIENCY OF DYNAMO-ELECTRIC MACHINERY.

BY ALFRED E. WIENER, E. E., M. E., MEM. AM. INST. E. E.

I. Electrical Efficiency.—The *electrical efficiency*, or the *economic coefficient*, of a dynamo is the ratio of its *useful* to the *total* electrical energy in its armature, and the latter is the sum of the output and of the energy-losses due to the armature and field resistances; hence the electrical efficiency is expressed by the formula

$$\eta_e = \frac{E \times C}{E \times C'} = \frac{P}{P'} = \frac{P}{P + P_a + P_f}, \qquad (1)$$

where η_e = electrical efficiency of machine; E = useful electromotive force, in volts; C = useful current, in amperes; E' = total E. M. F., in volts; C' = total current, in amperes; P = useful electrical energy, in watts; P' = total electrical energy, in watts; P_a = energy absorbed by armature winding, in watts; P_f = energy used for field excitation, in watts.

In case of a *generator*, P is the output available at the brushes, and P' the total electrical energy developed in the armature; in case of a *motor*, P is the energy actually effective in electromagnetic induction, while P' is the total energy delivered to the brushes, that is, the "*intake*" of the motor. The electrical efficiency does not include waste by hysteresis, eddy currents, or friction.

Inserting into (1) the values for P, P_a and P_f, viz., P = useful E. M. F $\times$ useful current, P_a = square of total armature current $\times$ armature resistance, and P_f = square of full exciting current $\times$ magnet resistance, we have the following formulæ for the electrical efficiency of series, shunt and compound-wound dynamos, respectively:

Series dynamo:

$$\eta_e = \frac{E \times C}{E \times C + C'^2 \times (r_a + r_{se})}; \qquad (2)$$

Shunt dynamo:

$$\eta_e = \frac{E \times C}{E \times C + C'^2 \times r_a + C^2_{sh} \times r_{sh}}; \qquad (3)$$

Compound dynamos:

$$\eta_e = \frac{E \times C}{E \times C + C'^2 \times (r_a + r_{se}) + C^2_{sh} \times r_{sh}}; \qquad (4)$$

in which $E \times C$ = useful electrical energy in watts; C' = total current flowing in armature conductors, in amperes; r_a = resistance of armature, hot, in ohms; r_{se} = resistance of series field winding, hot, in ohms; r_{sh} = resistance of shunt circuit, in ohms; C_{sh} = intensity of shunt exciting current, in amperes.

In the series-wound dynamo the whole current from the armature is carried through the field-magnet coils, the latter being wound with comparatively few turns of heavy copper wire, cable, or ribbon, and connected in series with the main circuit; hence the exciting current is in this case identical with the total armature current and also with the useful current. In the shunt-wound dynamo the field-magnet coils are wound with many turns of fine wire, and are connected to the brushes of the machine, constituting a by-pass circuit of high resistance through which only a small portion of the armature current passes; here, consequently, the field-exciting current, C_{sh}, forms only a part of the total armature current, C', and the useful current, C, is the difference between the total and the exciting currents. The field coils of a compound-wound dynamo, finally, are partly wound with fine wire and partly with heavy conductors, the fine winding being traversed by a shunt current and the heavy winding by the main current; the total armature current therefore passes through armature as well as series-field conductors, and a small portion of it excites the shunt winding, the useful current again being the total current minus the shunt current.

By replacing in (2), (3) and (4) the useful E. M. F., E, by the product of current-output and external resistance (by virtue of Ohm's law), and by expressing the total current, C', in terms of the current output, C (the currents flowing in a divided circuit being inversely proportional to the resistances of the respective branches), formulæ for η_e may be obtained which give the electrical efficiencies as functions of the resistances of the machine only. While it is thus found that in the series and compound dynamos the electrical efficiency is determined by the relative amounts of the internal and external resistances of the machine, the formula of the shunt dynamo, by a simple approximation, shows that the maximum electrical efficiency for that class of dynamos depends solely upon the ratio of shunt resistance to armature resistance, and is, therefore, in every single case given by the numerical value of that ratio. In the following Table I. these values are compiled for electrical efficiencies from η_e = ·8 to η_e = .995, or from 80 to 99.5 per cent.:

TABLE I. RATIO OF SHUNT TO ARMATURE RESISTANCE FOR DIFFERENT EFFICIENCIES.

Percentage of Electrical Efficiency, 100 η_e	Ratio of Shunt to Armature Resistance, $r_{sh} : r_a$	Percentage of Electrical Efficiency, 100 η_e	Ratio of Shunt to Armature Resistance, $r_{sh} : r_a$
80%	64	95.5%	1802
85	128	96	2304
87.5	196	96 5	3041
90	324	97	4182
91	409	97.5	6084
92	529	98	9604
93	706	98 5	17248
94	982	99	39204
95	1444	99.5	158:04

From this table the approximate electrical efficiency of any shunt-dynamo can be directly obtained if the armature and magnet resistance are known, or the shunt-resistance required to obtain a certain electrical efficiency may by its means be readily computed for the case when the armature resistance is given.

The electrical efficiency of modern dynamos is very high, ranging from η_e = .75, or 75 per cent., for the smallest machines to as high as η_e = .99, or 99 per cent., for very large generators.

II. Commercial Efficiency. — By the *commercial* or *net efficiency* of a dynamo-electric machine is meant the ratio of its output to its intake. The intake of a *generator* is the mechanical energy required to drive it, and is the sum of the total energy generated in the armature and of the energy-losses due to hysteresis, eddy currents, and friction; the intake of a *motor* is the electrical energy delivered to its terminals. The output of a *generator* is the electrical energy available at its terminals; the output of a *motor* is the mechanical energy at its shaft, and consists in the useful energy of the armature diminished by hysteresis, eddy current, and friction losses.

The intake of a generator, or the output of a motor, in foot-pounds per second, for the case of belt-driving, is the product of the belt-speed, in feet per second, by the effective driving force of the belt, in pounds; or, converted into watts:

$$P' = \frac{746}{550} \times \frac{v}{60} \times (F - f)$$

$$= 1.3564 \times v' \times (F - f),$$

where v = belt-velocity, in feet per minute; v' = belt-velocity, in feet per second; F = tension on tight side of belt, in pounds; f = tension on slack side of belt, in pounds. The commercial efficiency of a *generator*, therefore, is:

$$\eta_c = \frac{P}{P'} = \frac{E \times C}{1.3564 \times v' \times (F - f)}, \qquad (5)$$

and that of a *motor*

$$\eta_c = \frac{P'}{P} = \frac{1.3564 \times v' \times (F - f)}{E \times C'}. \qquad (6)$$

The energy supplied to a *generator* can also be expressed by

$$P' = P + P_a + P_f + P_o,$$

and, similarly, the output of a *motor* by

$$P' = P - (P_a + P_f + P_o);$$

hence, another formula for the commercial efficiency of a *generator* is:

$$\eta_c = \frac{P}{P'} = \frac{P}{P + P_a + P_f + P_o}, \qquad (7)$$

and for a *motor*

$$\eta_c = \frac{P'}{P} = \frac{P - (P_a + P_f + P_o)}{P'}, \qquad (8)$$

P_a and P_f denoting the energies consumed by armature winding and field excitation, respectively, and P_o being the energy loss due to air-resistance, brush-friction, bearing friction, brush contact resistance, hysteresis, and eddy currents, that is, the power required to run the machine unloaded, at normal speed.

The commercial efficiency, η_c, of a dynamo is always smaller than its electrical efficiency, η_e, since the former, besides the electrical energy-dissipation, includes all mechanical and magnetic energy-losses; the commercial efficiency, therefore, depends upon the amount of the electrical efficiency, upon the shape of the armature, upon the design, workmanship and alignment of the bearings, upon the pressure of the brushes, upon the quality of the iron employed in its armature and field magnets, and upon the degree of lamination of the armature core; while the electrical efficiency only varies with the resistances of the machine.

The commercial efficiency of well-designed machines ranges from η_c = .6, or 60 per cent., for small dynamos, to η_c = .95, or 95 per cent., for large ones.

Since in a *direct-driven* generator the commercial efficiency is the ratio of the mechanical power available at the engine shaft to the electrical energy at the machine terminals, for comparisons between direct and belt-driven dynamos the

loss in belting should also be included in the commercial efficiency of the belt-driven generator. The following Table II. contains averages of these losses for various arrangements of belts:

TABLE II. LOSSES IN DYNAMO BELTING.

Arrangement of Belts.	Loss in Belting in per cent. of Power Transmitted.
Horizontal belt........	5 to 10%
Vertical "	7 " 12%
Countershaft with horizontal belt...........	10 " 15%
Countershaft with vertical belt.............	12 " 20%
Main and counter shaft with belts...........	20 " 30%

III. Efficiency of Conversion.—The *efficiency of conversion*, or the *gross efficiency*, in a *generator* is the ratio between the total electrical energy generated in the armature and the gross mechanical power delivered to the shaft, and in a *motor* is the ratio of the mechanical output to the useful electrical energy; or, in symbols, for a *generator*:

$$\eta_g = \frac{P'}{P'} = \frac{P'}{P + P_a + P_i + P_o} = \frac{E' \times C'}{1.3564 \times v' \times (F - f)}, \quad (9)$$

and for a *motor*:

$$\eta_g = \frac{P'}{P} = \frac{P' - (P_a + P_i + P_o)}{P} = \frac{1.3564 \times v' \times (F - f)}{E \times C}, \quad (10)$$

The efficiency of conversion is the quotient of the commercial and the electrical efficiency, and therefore varies between $\eta_g = \frac{\eta_c}{\eta_e} = \frac{.6}{.75} = .8$, or 80 per cent., for small dynamos, and $\eta_g = \frac{.95}{.99} = .96$, or 96 per cent., for large machines.

TABLE III. EFFICIENCIES OF DYNAMOS.

Capacity of Dynamo, Kilowatts.	Commercial Efficiency, η_c	Electrical Efficiency, η_e	Gross Efficiency, η_g
1	.60	.75	.80
2	.67	.82	.82
5	.72	.85	.84
10	.75	.87	.86
15	.78	.89	.88
20	.80	.90	.89
25	.82	.91	.90
30	.84	.92	.91
40	.86	.93	.92
50	.87	.94	.93
75	.88	.945	.935
100	.89	.95	.94
150	.90	.955	.9425
200	.91	.96	.945
300	.92	.97	.9475
400	.93	.98	.95
500	.935	.9825	.9525
750	.94	.985	.955
1000	.945	.9875	.9775
2000	.95	.99	.96

In the accompanying Table III. the average commercial, electrical and gross efficiencies for dynamos of various sizes are compiled.

IV. Weight Efficiency and Cost of Dynamos.—As the commercial efficiency increases with the size of the machine, so the *weight-efficiency*, that is, the output per unit weight of the machine, in general, is greater for a large than for a small dynamo, and the cost of the machine per unit of the output therefore gradually increases as the output increases.

If all the different-sized machines of a firm were made of the same type, all having the same linear proportions, and if all had the same, or a gradually increasing, circumferential velocity, and were all figured for the same temperature increase in their windings, then the weight-efficiency would gradually increase according to a certain definite law, and the cost per kilowatt would decrease by a similar law. In practice, however, such definite laws do not exist for the following reasons: (1) Up to a certain output a bipolar type is usually employed, while for the larger capacities the multipolar types are more economical; and between the largest bipolar and the smallest multipolar size there will be a sudden jump in both the weight-efficiency and the specific cost. (2) The machines of the different capacities are not all built in linear proportion to each other, but, in order to economize material, tools and patterns, the outputs of two or three consecutive sizes are often varied by simply increasing the length of the armature and the pole pieces; in this case a small machine with a long armature may be of a greater weight-efficiency and of a smaller specific price than the next larger size with a short armature. (3) The conductor-velocity is not the same in all sizes; as a general rule it is higher in the larger machines, but often the increase from size to size is very irregular, causing deviation in the gradual increase of the weight-efficiency. (4) Certain sizes of machines being more popular than others, a greater number of these can be manufactured simultaneously, and therefore these sizes can be turned out cheaper than others, and the specific cost of such sizes will be smaller than that of the next larger ones. (5) Large generators frequently are fitted with special parts, such as devices for the simultaneous adjustment of the brushes, arrangements for operating switches, brackets for supporting the heavy main and cross-connecting cables, platforms, stairways, etc., the additional weight and cost of these extra parts often lowering the weight-efficiency and increasing the specific cost beyond those of smaller sizes not possessing such complications. These various reasons, then, show why prices differ so widely and the ratio of weight to output is so varied, and we see from all these considerations that the data derived from various makers' price-lists must necessarily differ more or less.

In the following Table IV. the writer has compiled the weights, list-prices, weight-efficiencies (watts per pound), and specific prices (dollars per kilowatt) for all sizes of dynamos, as averaged from the catalogues of numerous representative American manufacturers of high-grade electrical machinery:

TABLE IV. AVERAGE WEIGHT AND COST OF DYNAMOS.

Capacity, in Kilowatts.	Average Weight. (Total, Net.) lbs.	Weig't per Kilowatt, lbs.	Output per Pound, Watts.	Average Price (Complete), $	Price per Kilowatt, $.
.5	80	160	6.25	75	150
1	150	150	6.67	120	120
2	275	137	7.3	180	90
4	500	125	8	240	60
6	700	117	8.55	270	45
10	1100	110	9.1	400	40
15	1600	107	9.35	570	38
25	2600	101	9.6	875	35
50	5000	100	10	1650	33
75	7300	97.3	10.3	2400	32
100	9500	95	10.5	3100	31
150	14000	93.3	10.7	4500	30
200	18500	92.5	10.8	5800	29
300	27000	90	11.1	8400	28
400	35000	87.5	11.4	10600	27
500	42500	85	11.8	13000	26
600	50000	83.3	12	15000	25
700	58000	82.9	12.1	16800	24
800	65000	81.3	12.3	18400	23
1000	80000	80	12.5	22000	22
1500	120000	80	12.5	31500	21
2000	160000	80	12.5	40000	20

As it is usual to make very small machines for high speeds only, while medium-sized and large machines are built for high, medium, and low speed, the averages given above for the larger machines refer to medium speed, and must be proportionately reduced for high, and increased for low, speeds.

A Quaker Sir Boyle Roche.

Our sprightly London contemporary, *Lightning*, in its report of a recent meeting of the English Institution of Electrical Engineers, relates that Prof. Silvanus P. Thompson, in commenting upon an invention described in a paper read by Mr. Mordey which was under discussion, remarked: "It was a thing any fool might have thought of any time the last dozen years, but in fact no fool *did* think of it till the year of grace 1897." "Mr. Mordey," *Lightning* continues, "looked up quickly, wondering why the Professor called him a fool, and the audience, tumbling to the joke, roared with laughter. Prof. Thompson tried immediately to undo his error: 'Exceeding obvious as the thing was, *we didn't see it*; and it took a wise man to discover what so many fools had missed for so long."'

Gas Engine Central Stations.

The central station at Coatbridge, Scotland, has superseded its gas-engine plant by a steam-power plant, the cost of operation with the former having been found excessive. On the other hand, a gas-engine station at Leicester, England, is giving excellent results, the fuel economy greatly exceeding that of any English steam-driven station, corresponding to but .4 cents per KW-hour.

MEASUREMENT OF ALTERNATING CURRENT POWER.

BY PROF. A. F. MCKISSICK.

The measurement of power in a direct-current circuit is a very easy matter, consisting simply in multiplying the amperes (measured with an ammeter) by the pressure in volts (measured with a voltmeter), the result giving power expressed in watts. Another method would be to use a wattmeter (Fig. 1), connecting the series coil with one main, the pressure coil being connected in shunt across the two mains, as shown in Fig. 1, the reading then giving directly the number of watts.

FIG. 1.—PORTABLE WATTMETER.

The wattmeter of the portable type illustrated is made in sizes varying from a minimum current of 2 amperes in series coil, with 75 or 150 volts at terminals of pressure coil, to a maximum current of 200 amperes in series coil, with 75 or 150 volts at terminals of pressure coil. For higher pressures a multiplier can be used, and is connected as shown in Fig. 2. These multipliers are made for different ranges, varying from 300 volts to 3000. With the multiplier in circuit, the wattmeter reading must be multiplied by a factor to get the actual number of watts, this factor being the ratio of the capacity in volts with multiplier to the capacity without multiplier.

When we come to measure alternating currents we find that it is not as simple as the measurement of direct-current power. The power of an alternating current cannot be calculated by multiplying together the volts and the amperes, as with direct currents. This product of current and volts gives what is termed *apparent watts,* which differs from the true power, termed *true watts.* When there is no *inductive resistance* in circuit, the apparent watts and the true watts will equal each other, but when there is any inductive resistance in circuit, causing a *phase difference* between the current and the E. M. F., the apparent watts will be greater than the true watts. The ratio of the true watts to the apparent watts is termed the *power factor.*

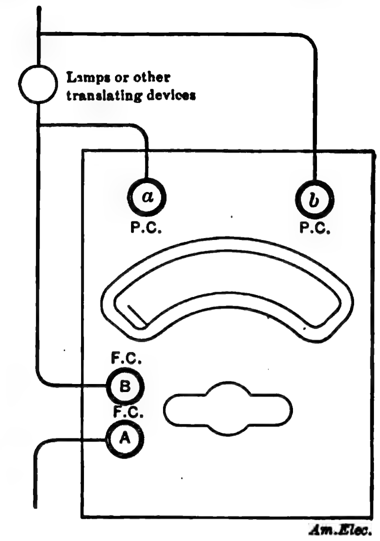


FIG. 2.—WATTMETER CONNECTIONS FOR SINGLE-PHASE CIRCUIT.

For the measurement of the true watts of an alternating-current circuit, a wattmeter is the most convenient to be used. The wattmeter shown in Fig. 1 will measure alternating watts as readily as direct-current watts, the remarks concerning the multiplier being applicable to alternating currents, inasmuch as the multipliers offer no inductive resistance. Methods for the measurement of power in single phase, two-phase and three-phase circuits will be given:

Single-Phase Circuits.—Connections are made as in Fig. 1, a multiplier being used if the pressure exceds 150 volts. The wattmeter reading (multiplied by factor, if multiplier is used) will give *true watts,* the product of the volts and amperes giving apparent watts.

Two-Phase Circuits.—In the two-phase system the power can be measured by placing a wattmeter in each of the circuits, as in the single phase, the total true watts being the sum of the watts in each circuit. If the circuits are balanced, the total power will be the reading on one wattmeter multiplied by two. If the circuits are not balanced, two wattmeters will have to be used.

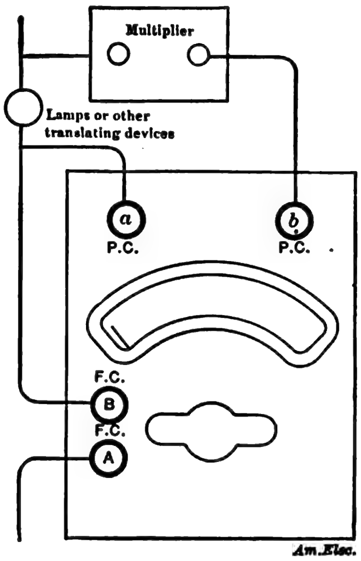


FIG. 3.—WATTMETER CONNECTIONS FOR SINGLE-PHASE CIRCUIT, WITH MULTIPLIER.

If the circuits are balanced, the *total* apparent watts may be obtained by multiplying the apparent watts of one circuit by two, but if the circuits are not balanced, the total apparent watts can only be obtained by taking the sum of the apparent watts in each circuit.

By using the connections shown in Fig. 3, one wattmeter, one ammeter and one voltmeter can be made to take the readings. In order to be correct, the readings on the two circuits should be taken simultaneously, but if the load is not very variable the readings with the connections, as shown in Fig. 3, can be taken within a few seconds of each other, and will be sufficiently accurate for all practical purposes. Several readings should, of course, be taken in order to get a fair average.

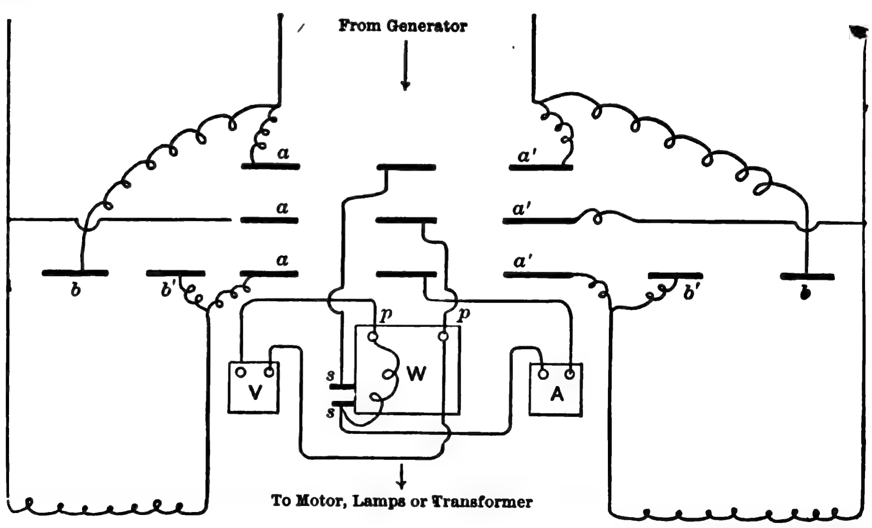


FIG. 4.—WATTMETER CONNECTIONS FOR TWO-PHASE CIRCUIT.

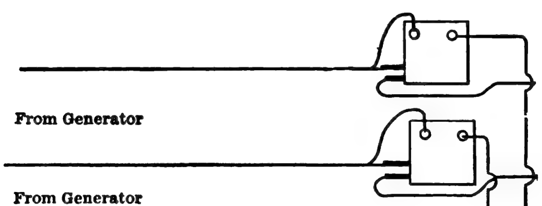


FIG. 5.—WATTMETER CONNECTIONS FOR THREE-PHASE CIRCUIT.

In Fig. 4 *a a a* and *a' a' a'* are the jaws of a triple-pole, double-throw switch; *b b* and *b' b'* are the jaws of single-throw switches (single pole); *p p* are the ter-

minals of the pressure coil of the wattmeter; *s s* the terminals of the series coil; *A* an ammeter, and *V* a voltmeter.

Before taking a reading the single-pole switches should, of course, be closed. In order to take readings on left-hand circuit, throw the triple-pole switch to jaws *a a a*, and open the single-pole switch *b b*. Take readings and close switch *b b*. To take readings on right-hand side, throw the triple-pole switch to jaws *a' a' a'* and open the single-pole switch *b' b'* and take readings.

Three-Phase Circuits.—In order to measure the power in a three-phase circuit, the following connections can be used (Fig. 4). In this case the total true watts are the sum of the two wattmeter readings. If

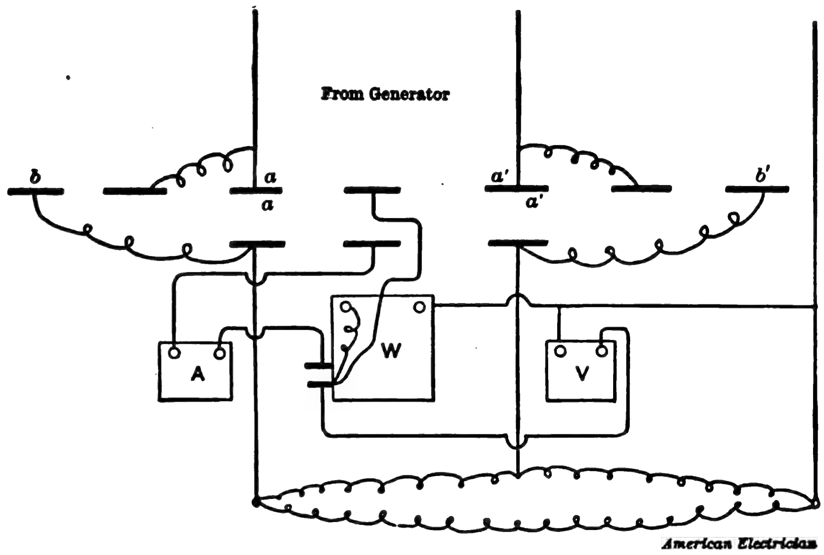


FIG. 6.—WATTMETER CONNECTIONS FOR THREE-PHASE CIRCUIT

the power factor is less than 50 per cent., the readings of one of the wattmeters will be negative. The connections to this meter (either the series or the pressure connections) will have to be reversed, the total true watts being then the difference of the two readings, and not the sum.

The total apparent watts are obtained by multiplying the voltage between the lines by the current in the lines, and this by the factor 1.73.

By using the connections shown in Fig. 5, one set of instruments can be made to take all the readings.

In this figure *a a* and *a' a'* are the jaws of a double-pole, double-throw switch, *b* and *b'* the jaws of two single-pole, single-throw switches; *W*, a wattmeter; *V*, a voltmeter, and *A*, an ammeter.

To take a reading, close the single-pole switches *b b* and *b' b'*, which completes the connections to the apparatus, the power supplied to which is to be measured.

For reading on left-hand side, throw witch jaws of double-pole, double-throw switch to *a a*, and open *b b*. This gives us readings on wattmeter, voltmeter and ammeter. Now close switch *b*, and throw double-throw, double-pole switch to jaws *a' a'*, and open switch *b' b'*. This gives us readings for the middle branch.

These readings have to be taken very quickly, and can be relied upon if the load is not very fluctuating.

DYNAMO CHARACTERISTICS.

BY PROF. WILBUR M. STINE.

The Series Curve.—A dynamo operated as a shunt machine suffers a diminution of the brush voltage as the load increases. This decrease of voltage is due to two causes—armature reaction, which has already been alluded to and partially explained, and the drop due to the resistance of the armature itself. For dynamos working on constant-potential circuits it is not only necessary that they have a fixed voltage throughout all ranges of load, but to compensate for the drop on the circuits themselves such dynamos must be constructed to increase the voltage delivered to the line proportionally to the load. This is accomplished by an over-compounding of the dynamos through the series coil.

An analysis of a dynamo must then include a careful study of this very important feature. To this end a series curve is taken. The connections are shown in Fig. 1. The shunt coils are left on open circuit; a voltmeter is connected to the brushes, and the external circuit is closed through an ammeter and a suitable low resistance, capable of a wide range of adjustment. The dynamo should be operated at

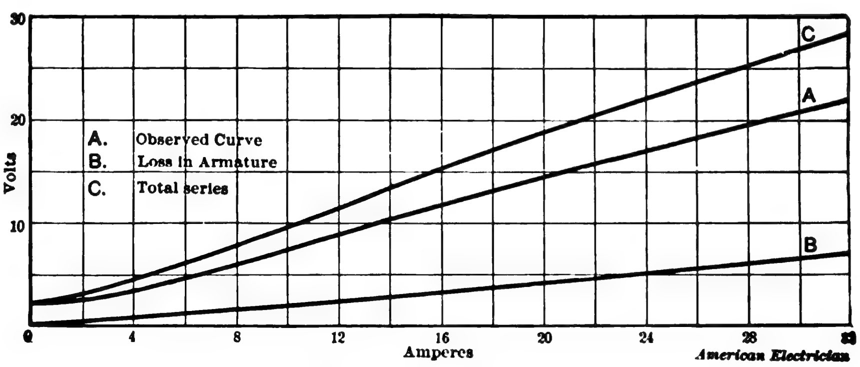


FIG. 2.—SERIES CURVE.

normal speed, and this maintained constant throughout the test, otherwise the voltmeter readings will not be co-ordinate. The current is increased step by step until the normal carrying capacity of the armature has been reached, the voltmeter and ammeter readings being taken simultaneously.

The data for such a test on the 4-KW dynamo already alluded to are given in Table I. This is shown platted in Fig. 2. Here the curve *A*, called the "observed curve,"

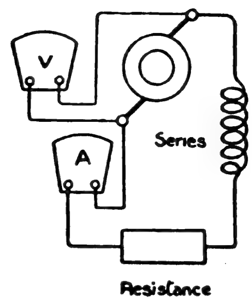


FIG. 1.—CONNECTIONS FOR SERIES CURVE.

refers directly to the readings of the ammeter and voltmeter. Its aim is to exhibit the volts which the series winding contributes for all loads. But it is evident that the voltmeter has read too low, to the extent of the drop over the armature itself. To correct for this, the curve for the armature resistance drop must be calculated for the same range of current. This implies

TABLE I.—SERIES CURVE.

Volts	Amperes	Volts	Amperes	Volts	Amperes	Volts	Amperes
1.85	0	5	7	10.2	14	14.75	21
2.35	1	6.8	8	10.7	15	16	25
2.7	2	6.9	9	11.4	16	17	26
3.18	3	7.54	10	12.82	17	21.75	32
3.75	4	8.2	11	12.9	18		
4.3	5	8.5	12	14.25	19		
4.97	6	9.58	13	14.5	20		

that the resistance must be measured, and this may be done either by direct measurement or by observing the drop over the armature when a known current is sent through it.

The latter method is apt to give the more accurate result on account of the low resistance of the armature. The commutator and brushes should be first carefully cleaned and the brushes adjusted as for normal running. A current from some suitable source of E. M. F. is then sent through the armature, and is measured by an ammeter placed in the circuit. The terminals of a voltmeter are pressed on opposite commutator segments, in contact with the brushes. Several readings are to be taken, the armature being turned forward a little each time. The average drop,

E over the armature is thus ascertained and the resistance is calculated by Ohm's law, $R = \frac{E}{C}$.

From the resistance factor and the current values of curve A, curve B is platted. A third curve, C, is then platted by adding together the voltage values of curves A and B for the current points noted. The curve C, called the "total series curve," is the real data sought, and exhibits the total voltage which the series winding contributes to the circuit.

The Normal Compound Curve.—It has

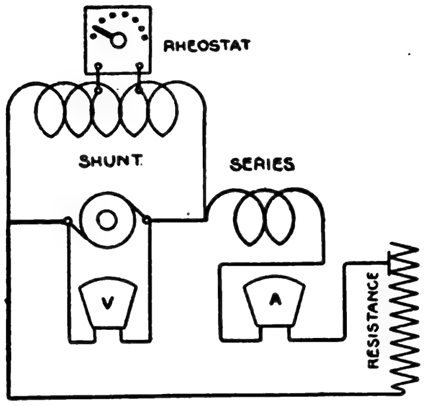


FIG. 3.—CONNECTIONS FOR COMPOUND CURVE.

been stated above that the series coils compensate for the drop over the armature and for the armature reaction. Consider, now, what occurs when the dynamo is normally

TABLE II.—COMPOUND CURVE.

Volts	Amperes	Volts	Amperes	Volts	Amperes	Volts	Amperes
110.5	0	121.3	8	129	17	135 3	32
110.7	1	122	9	130.5	19	136	34 5
111 5	2	122.3	10	130.5	20	136.5	35.5
112.	3	123.3	11	131	22		
116.	4.5	123.8	12	133	24		
117.3	5.25	124	14	133.8	25		
118.	6	124.3	15	134	27		
118.5	7	126	16	135	28		

connected and supplying a varying current to the line. The shunt coil is essentially connected across the brushes, and if the series coil is adjusted so as to simply

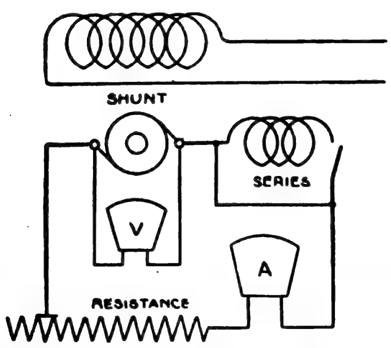


FIG. 5.—CONNECTIONS FOR EXTERNAL SHUNT CURVE.

compound the dynamo, the brush voltage will remain constant throughout all changes in the load, and in consequence the current through the shunt field will remain constant. But few, if any, dynamos are so adjusted, all being constructed for varying amounts of over-compounding. As a result the voltage at the brushes increased slightly with the load and there is a proportional increase of current through the shunt field. The total compounding of such a dynamo is the result of the increase of its field strength, due to the joint action of the series and shunt windings.

The curve which illustrates this is shown in Fig. 4. It was platted from the data given in Table II., obtained from the 4-KW dynamo at a speed of 1,375 r. p. m. The connections for this curve are shown in Fig. 3. The dynamo is run at a constant speed throughout the test. The rheostat is set at the usual point for normal operation and should not be changed. A voltmeter is connected across the brushes and an ammeter placed in the external circuit. The load may be absorbed by a water rheostat, or banks of incandescent lamps, if the dynamo is a small one. Simultaneous readings of both the voltmeter and ammeter are taken at frequent intervals throughout the range of the load. It is well to push the load to an excess of about 25 per cent. above the normal rating, for in some cases the curve will drop off rapidly after the rated output is passed, owing to excessive armature reaction.

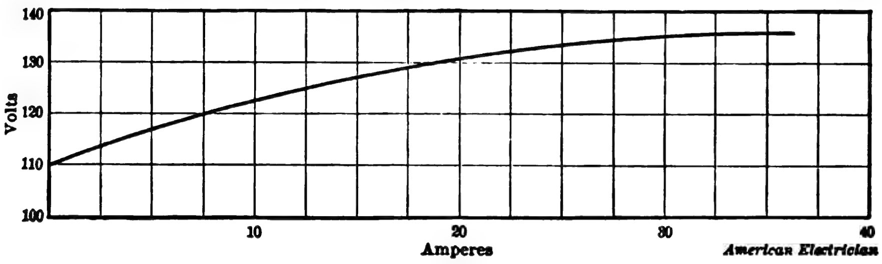


FIG. 4.—COMPOUND CURVE.

There are several noticeable features about this particular curve. Ordinarily the "compound" curve is a straight line, inclined to the horizontal reference line, more or less according to design. In this case it is a convex curve, showing that the field is worked too high. The saturation of the field is marked at about ¼ load, with the result that for higher loads the curve falls off. This is a case of poor design or the use of poorer iron than the design specified. The over-compounding is excessive and amounts to 26 volts or nearly 24 per cent. This unequal increase in the compounding is also due in part to the effect of the armature reaction, which is disproportionately increased with the higher load. This is apparent on examination of the following curve.

External Shunt Curve. Separate Excitation.—To complete this elementary series of curves an additional factor in the operation of this dynamo must be graphically exhibited—the extent of its armature reaction. In the preceding paper of this serial an explanation of the demagnetizing effect of the back turns was presented. It now remains to show the extent of this action.

For this test the connections are made as shown in Fig. 5, the dynamo being excited through the shunt field from a separate source of E. M. F. The speed again should be kept constant throughout the test. The excitation is adjusted to produce normal voltage with no load on the dynamo, and the rheostat should remain at this setting. The series field is to be kept on open circuit, connections being run directly from the brushes to the rheostat for absorbing the

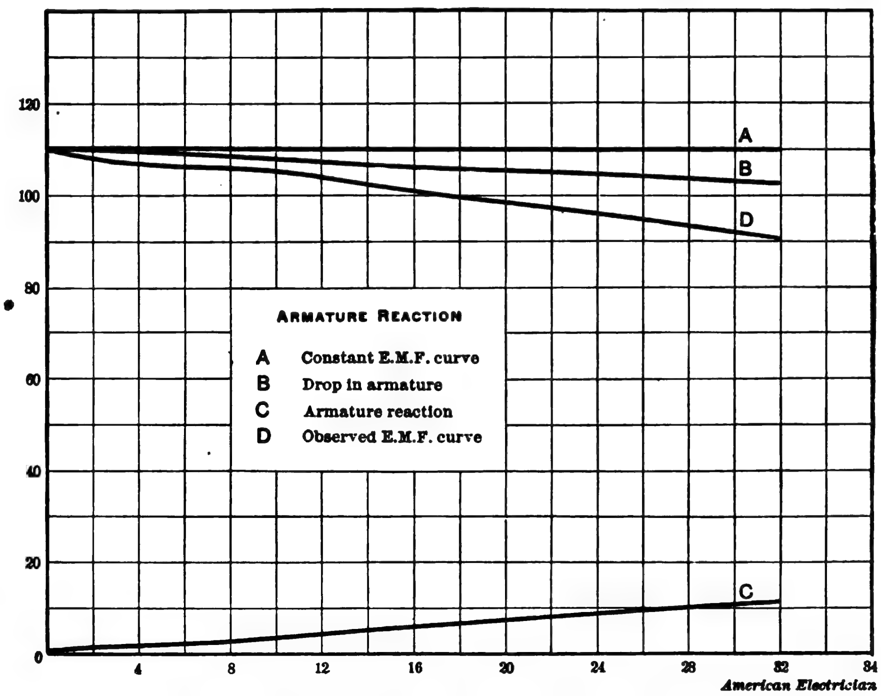


FIG. 6.—EXTERNAL SHUNT CURVE, SEPARATELY EXCITED.

load. The armature current is then increased step by step until normal load, or better, 20 per cent. overload, is reached. Both voltmeter and ammeter readings are to be taken simultaneously for each adjustment of the current. The data for this 4 KW dynamo under this test are given in

Table III; while from these readings the curves shown in Fig. 6 were platted. The curve, *A*, is drawn parallel with the horizontal reference line, indicating that since the excitation of the field was constant the E. M. F. at the brushes would have followed this line, provided there was no demagnetizing action at work on the field. *D* is a curve platted over the readings in Table III. The deficit in this curve over

TABLE III.

EXTERNAL SHUNT CURVE—SEPARATELY EXCITED.

Volts.	Amperes.	Volts.	Amperes.	Volts.	Amperes.
110	0	103	12	94	28
100	1	102	14	93	30
108.2	2	101	16	92	32
108	3	100	18	...	...
108	4	90	20	...	...
107	6	97.2	22	...	...
106	8	96	22	...	...
105	10	95	26	...	...

the constant E. M. F. curve is due to two causes; one is the drop over the resistance of the armature, and from previous data is platted as curve *B*. The difference between the curves *D* and *B* is then clearly due to a cause at work demagnetizing the field. This difference is platted as curve *C*, and exhibits the amount of armature reaction for this particular dynamo.

ELECTRIC LIGHT PLANT OF THE COLUMBUS STATE HOSPITAL.

BY PROF. E. P. ROBERTS.

The new plant of the Columbus State Hospital consists of two 40-KW and one 20-KW Triumph dynamos, direct connected to Buffalo Forge engines, and furnishing current to 1600 incandescent and ten arc lights.

FIG. 1.—GENERATING PLANT.

Before entering into a detailed description of the plant, it is instructive to consider the conditions controlling its design. These conditions were, as is usually the case, of two general classes: First, technical conditions, and second, financial conditions. The engineers, in studying the case, were first informed as to the second condition, and then it was necessary for them to design a plant which would, with the amount available, satisfactorily fulfill the first condition. Taking it, therefore, in the order in which it was presented to them, we find that $15,000 was the appropriation provided by the state for the electric light plant. The Ohio State Law requires that before advertising state work, there shall be filed with the Secretary of State copies of the specifications and drawings which are to be used in connection with the work, and a detailed estimate as to the cost; and that, if the bids exceed either the appropriation or the estimate, the contract cannot be let until it has been readvertised and bids obtained which do not exceed such amounts. In case of such action being necessary, a month's delay results, and it does not add to the reputation of the engineer. Exceptional care is, therefore, needed in preparing the specifications and the estimate. In the case in hand, the first estimate to be prepared was necessarily that of the wiring, and the balance was then known to be available for engines, dynamos, switchboard and chandeliers.

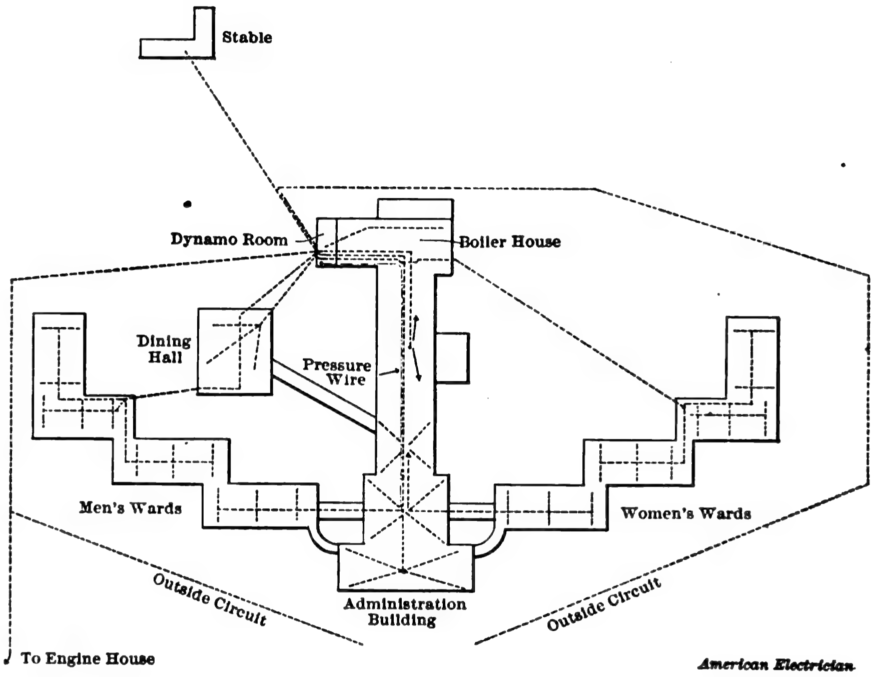


FIG. 2.—GENERAL PLAN OF BUILDING.

Wiring.—The building is a large structure having a general floor plan as shown in Fig. 2. In the front center is the Administration building having wings on each side, and an L extending back to the boiler house, shops and engine room. Each wing consists of four parts, the first three of which have axes parallel to the main building and offsetting the width of each building. The fourth wing is at right angles to the others. The Administration building is used for the offices, and is five stories high, and the wings for the patients are all from four to five stories high exclusive of the basement. In the L are the amusement hall, chapel, kitchen, laundry, etc., and also the rooms for the employes; also the ice machine room, cold storage space, etc. At the extremity of the L are a boiler house, machine shop, carpenter shop, tin shop and engine room. The main dining hall is back of one of the wings and a large stable and diary are located as shown. The length of the building is 1500 ft. and the distance around is 1¼ miles. The building is of brick, with brick floors, on top of which is placed a wooden flooring. It was desired that all the wiring, with the exception of that in the basement, should be concealed work. All the concealed wiring is in American circular loom conduit and placed on the loop system. The general arrangement of the wiring is as follows:

A large feeder runs to the attic in the L immediately back of the Administration building and feeds that building, the adjacent wings and the portion of the L nearest to the Administration building, which includes the amusement hall and the chapel. From the ends of this feeder, pressure wires

are brought back to the switch-board, this being the most desirable point to keep at a constant potential. Another feeder provides for the light at the end of the L nearest to the dynamo room. Another pair of feeders goes to each wing, running to a point in the third division of the wing, and distributing from such point to the second, third and fourth portions of the wing. Another feeder runs to the dining hall, and still another to the stable, and two others provide for lighting the grounds. At the end of each feeder in the main building is a distribution cabinet with switches and fuses. From such cabinets wires are run to the various cabinets on each floor. These wires are run mainly in ventilating air ducts which, fortunately, were in place.

In the Administration building there are no special features other than the fact, which is the case throughout the entire building, that there are no fuses except in cabinets. In the amusement hall a special fixture is designed which has proved very satisfactory. The decoration of the ceiling consists of a circle about 7 ft. in diameter, surrounded by an octagon about 15 ft. in diameter. The engineers therefore designed a brass fixture consisting of a circle of the same diameter as the above, having twenty-four lights appended, and having eight radial arms independent of the circle and running from the circle up to the angles of the octagon. On each of these arms are eight single lights, and a three-light pendant cluster at the upper end; at the inner end is a neat brass ornament which hides the joint between the arm and the circle. Each of the arms and the circle can be lowered to the floor for the replacing of lamps, the cable connections in the attic over the ceiling being readily disconnected. The wiring to the chandeliers is so designed as to give a drop of about one volt more than for the other lights in order to lessen the probability of straining of the lamps. Also, instructions were given the engineer in charge not to replace broken lamps from stock, but from lamps which had burned at least three or four days; lamp renewals, therefore, for this fixture will be very few. At one end of the hall is a stage lighted in the customary manner, and at the other end a gallery with a row along the front of same.

The lighting of this room has been much commented upon as being exceptionally satisfactory. As the floor of the stage projects somewhat beyond the rostrum arch, it was advisable to provide lights additional to the foot-lights, and advantage was taken of a recess between two columns to place a vertical row of lights to each side of the stage, covering the same with a tin reflector, and painting the side toward the audience in such a way as not to be noticeable.

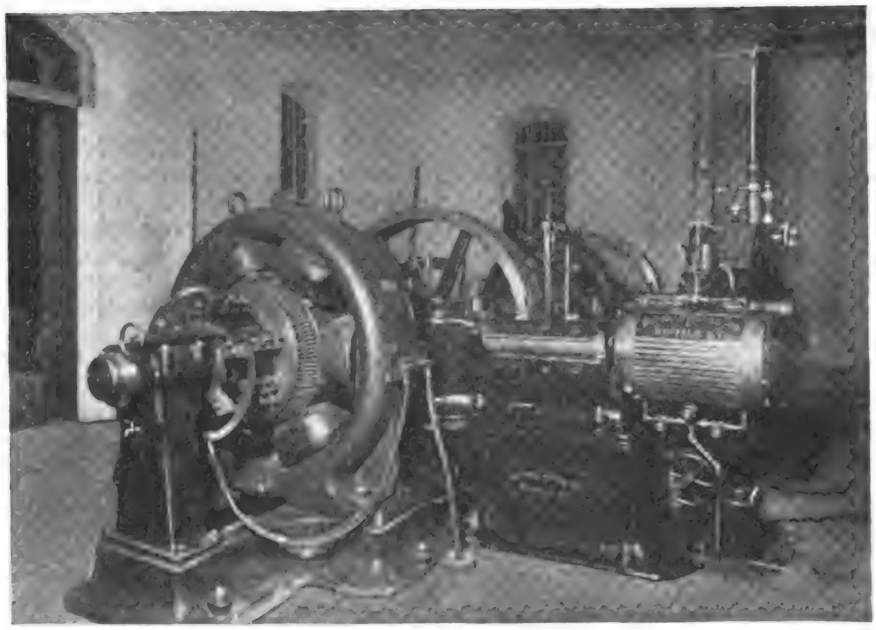
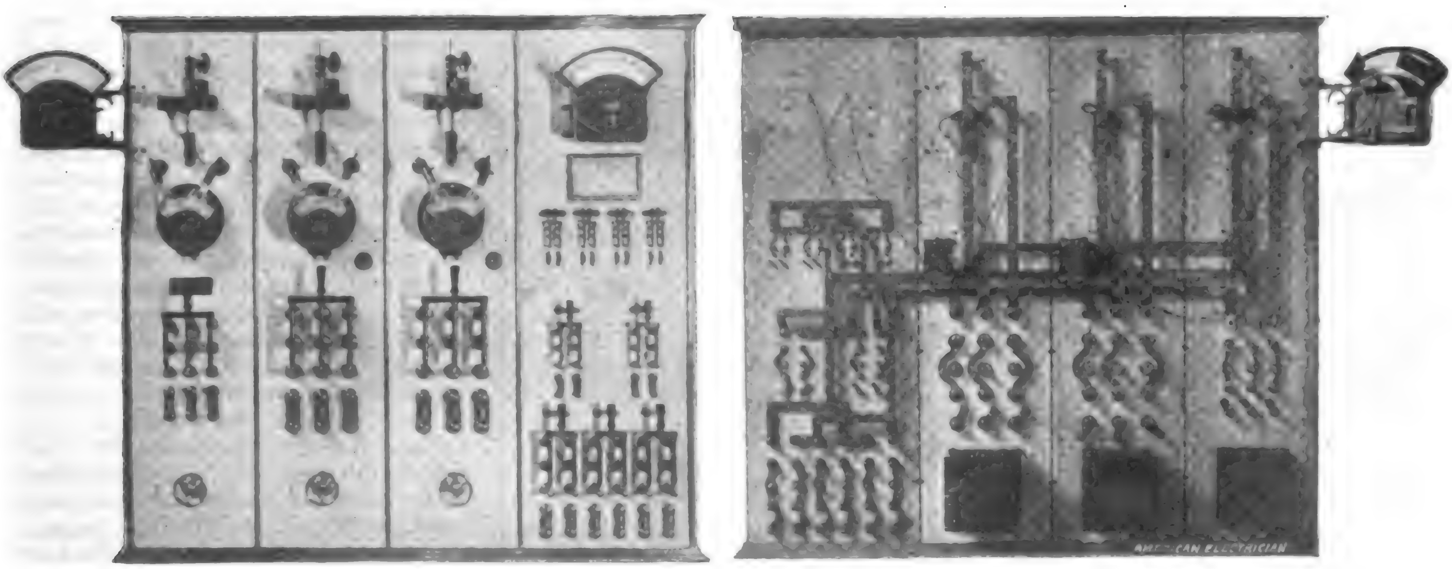


FIG. 3.—GENERATING UNIT.

Lighting of the Wings.—Each floor in the wings consists of a long central hall, with small rooms for the patients opening from such hall, and also with two or three rooms for the attendants. The central hall is fitted with lounges, etc., and is used as a sitting room. In the center of each wing is an alcove especially fitted up for those desiring to read. The halls and this alcove are lighted by chandeliers, all of which are controlled from the attendants' rooms. At several places on each hall there is also a locked box, containing sockets into which can be inserted a cable long enough to reach into the adjacent patients' rooms whenever light in such rooms is necessary, which is seldom the case, and only desired for a short time. In the large dining hall long-burning enclosed arc lamps of the Manhattan Company's manufacture are used for the outside circuit. The same arc lamps are used from the Administration building to the main entrance to the grounds, and 50-CP incandescent lamps for the balance of the circuits about the building.



FIGS. 4 AND 5.—FRONT AND REAR VIEWS OF SWITCHBOARD.

Cabinets.—The cabinets have slate backs and sides, are sunk into the wall, and have locked doors, with galvanized-iron coating inside of the door. The fuse boxes are Edison mica-covered boxes, and special pains have been taken throughout to provide a perfectly safe installation, and one which cannot be tampered with by the patients.

The following table, taken from the specifications, shows the large amount of wire and conduit used, and also indicates to some extent the care and detail with which the speci-

fications were prepared. The heading "C" is for American circular loom conduit, "M" for moulding, and "Ins." for insulators. In all, 360 switches and 322 cut-outs were used.

After preparing the specifications for the wiring, an estimate was made that the same would cost $7500. Six bids were obtained, the lowest of which was $7225; the next, $7590; the next, $7881.

Generating Plant.—Having decided upon the number of lights, a table was prepared showing approximately the anticipated ampere output for each hour during operation. This table indicated that two 40-KW machines and one of 20-KW would furnish sufficient current at all times, and that each would be fully loaded during its time of use; consequently specifications were prepared for such sizes. By partitioning in the end of one of the shops not far distant from the boiler room, sufficient space was obtained for the installation of three direct-connected sets. The contract was awarded The Triumph Electric Company, to furnish dynamos of its make, direct-connected to the Buffalo Forge Company's engines. The combined efficiency of engine and dynamo was to be not less than 78 per cent., and the heating after an eight hours run at full load not over 75 deg. F. above the temperature of the surrounding atmosphere, and that the point of commutation should not vary from no load to full load; the mechanical and electrical matters connected with the engine and dynamo were rigidly specified and a test showed that in every respect the engines and dynamos were well adapted to their work.

On the switch-board Weston instruments are used, including a Weston differential voltmeter for throwing dynamos in and out of circuit. Under the main voltmeter may be noted a glass-covered receptacle for a card. On this card is printed the insulation resistance corresponding to the various deflections of the voltmeter when connected to ground, which can be done by a multiple-contact switch.

This plant has been in continuous operation during the past winter, and has given such satisfaction to the trustees and the superintendent, Dr. A. B. Richardson, that they thought it proper to make special mention of same in their annual report. The engineers for the plant were E. P. Roberts & Company, of Cleveland, O.

BILL OF MATERIAL.

Building.	Outlets.	Lamps.	No. 14. C.	No. 14. M.	No. 12. C.	No. 12. M.	No. 10 C.	No. 6. C.	No. 6. Ins.	No. 4 C.	No. 2 Ins.	No. 1 Ins.
Stable	25	25	100	1100		100						
Dining Room	8	8	100									
Boiler House				350	225							
Administration Building Basement	43	45		2000		400	400					
" " L 1st floor	49	50		2000		500	300					
" " L, 2d and 3d floors	70	110		4000		1000						
" " 1st floor	52	91	1900		500							
" " 2d "	36	77	1550		325							
" " 3d "	35	62	1580		300							
" " 4th "	35	62	1580		300							
Amusement Hall	86	180	200	2040			240					
Chapel	7	25	200	200								
South Wing, Section 1	70	116	3710		2120							
" " " 2	71	111	3500		2000							
" " " 3	77	121	3800		2200							
" " " 4	39	57	1800		1620							
North " " 1	70	116	3710		2120							
" " " 2	71	111	3500		2000							
" " " 3	77	121	3800		2200							
" " " 4	39	57	1800		1620							
Three circuits to under side of galleries to Dining Room				200								
Dining Hall in basement	25	37		1800		200						
Mains and Risers in wings							1800	900	600		1800	800
Branches to wings, Section 1, Risers in Administration Bldg.							600	600		800		
Total	985	1591	32890	14190	17530	2200	3340	1500	600	800	1800	800

The wire is given double distance.

THERMO-ELECTRIC BATTERIES.

In the June issue of the AMERICAN ELECTRICIAN, Prof. W. A. Anthony and Mr. Willard E. Case have objected to some of my statements regarding thermo-electric batteries.*

In reply to Professor Anthony, I would say that the questions raised by him on the Jacques cell have been fully answered by me elsewhere. Dr. Jacques stated several months ago that the full current and electromotive force are maintained in his cell when the entire apparatus is enclosed in a uniformly-heated chamber. The prediction of Professor Anthony is, therefore, perfectly correct. The fact that the entire apparatus was enclosed in a uniformly-heated chamber is no proof, however, that all parts of the enclosed cell were at the same temperature. In the absence of any detailed statement of the arrangement by Dr. Jacques, the inference is, that in his experiment the current of air was continually blown into the cell. This would certainly nullify the effects of the uniformly-heated chamber, unless the current of air were previously heated to exactly the same temperature. Whether this was done, and if so, how the different parts of the apparatus were found to be at the same temperature, Dr. Jacques has not stated. Admitting that all the materials within the enclosure might have been originally at the same temperature, this uniformity of temperature could not remain undisturbed while a strong electric current was flowing through the apparatus, owing to the Peltier and Thomson effects, which in this cell are very powerful and which would be continually transferring heat from one part of the apparatus to another. The burden of proof lies, therefore, on those who claim that all parts of the apparatus were or could be maintained at the same temperature. The difference in temperature due to the current of air would be sufficient to produce the observed electromotive force, even if iron had been used instead of carbon.

Professor Anthony says that a Daniell cell would not become a thermo electric cell by being transferred to the polar regions, where heat would be required to thaw it out. That statement is undoubtedly correct, but it does not concern or illustrate the question at issue. There is an essential difference between the nature of the chemical reactions of the Daniell cell and the chemical reactions in the Jacques cell. In the Daniell cell the chemical reactions alone must necessarily evolve energy, while in the Jacques cell the chemical reactions alone must necessarily absorb energy. If the action of the Daniell cell resulted in the oxidation of copper and precipitation of metallic zinc, instead of the oxidation of zinc and precipitation of copper, we should know that its action did not evolve electrical energy or any other form of energy, simply because the products of the reaction would contain more potential energy than the reagents employed. In other words, the formation heat of zinc sulphate is greater than that of copper sulphate; and this would be true, whether we happened to be living at the polar regions or in Hades.

I have shown elsewhere that in the Jacques cell the oxidization of carbon to CO_2 could not evolve energy enough to reduce any substance in the cell, which would be necessary if the fused alkali is an electrolyte. I admit that this proof rests upon one assumption—the assumption that in all galvanic or electrolytic cells chemical action takes place at both electrodes. It has been claimed by some that the Jacques cell is an exception to this otherwise universal rule, but I think it has not been proved.

Prof. Anthony's statement that the operation of the Jacques cell does not require the continuous application of heat, but only requires that the temperature shall be sufficiently high, applies also to any other thermo-electric couple. If all the parts of any thermo-electric cell be raised to a sufficiently high temperature, it only requires for the operation of the cell the application of a current of cold air to the junction, such as is employed in the Jacques cell. If such an arrangement would not answer for a source of heat and a refrigerator, I can conceive of no arrangement that would.

Prof. Anthony's remarks on the "tin-chromic-chloride" cell seem to have been made without due consideration of the facts stated by Mr. Case. Prof. Anthony suggests that if we happen to be living at the high temperature at which the cell gives an electric current, we could maintain the cell in action by "renewing the materials as they were consumed, exactly as we now renew the materials of a gravity cell." We always renew a gravity cell by putting in materials that contain chemical energy and removing materials from which the available chemical energy has been exhausted. In other words, we renew the gravity cell by adding potential energy to it. But Mr. Case renews his exhausted materials by the simple act of cooling them, that is, by abstracting more

*AMERICAN ELECTRICIAN, April, 1897.

energy from them. He abstracts heat from the chemicals at the low temperature and electrical energy at the high temperature. Do they not then constitute an inexhaustible source? If the chemical change which takes place on cooling absorbs energy, it necessarily absorbs it at a lower temperature than the high temperature at which that change reverses. If Prof. Anthony's theory is correct, he must admit, either that the energy absorbed by a chemical reaction is different in amount from that evolved by its reversal, or else that a given quantity of heat may be absorbed by a body of matter at a low temperature and evolved without loss at a higher temperature and also in a higher form.

In reply to Mr. Case, I may say that I have not denied that he or others may have oxidized carbon at low temperatures without expending upon it in some form more energy than could be derived from it. I only stated that no researches indicating that fact had yet been published. Contrary to the belief of Mr. Case, that statement was correct. No such research has been published. There is nothing in the paper referred to by Mr. Case to indicate that any research was made by him or others to determine this question. He describes in that paper some experiments with a galvanic battery containing certain chemicals, and states that certain electrical indications resulted. He gives no data, however, to show that a research was made, such as would indicate that carbon was oxidized in those experiments. He gives the composition of several varieties of impure carbon or carbon compounds that he used as electrodes in his galvanic battery, and he states the *volts* obtained in several experiments, but no other figures except some questionable calculations as to the theoretical electromotive force of carbon. In one of these experiments he appears to have obtained an electromotive force nearly 25 per cent. greater than could be obtained theorectically from the oxidation of carbon to the dioxide. The rest of the paper deals with inferences. Inferences are not researches.

If Mr. Case made any research upon the oxidation of carbon, he should have stated in detail his method of procedure and the quantitative measurements that were made. He should have stated how the carbon experimented upon was prepared, how its purity was determined, what quantity of carbon was used in his research, the quantity of each of the products and residues obtained, the amount of carbon that remained undissolved, how these quantities and products were determined and his results checked. In other words, if Mr. Case had published his researches instead of his inferences, we might have known whether he had oxidized carbon in the manner stated; and his results, like the researches of Rowland or Morley or Langley, would have stood unchallenged until proved incorrect by a subsequent and more accurate research. But nothing of the kind is to be found in the paper referred to by Mr. Case. It is difficult to determine from that paper whether his electrical experiment constituted also his chemical analysis or not, and whether it was made with the aid of an analytical balance or a voltmeter.

The time is passed when an alchemist may claim to have discovered the philosopher's stone or to have transmuted lead into gold and exhibit in proof of his claim a beautiful sample of the yellow metal. He must show that the gold was produced from the lead. It matters not how great the man may be, or how illustrious the institution to which he points for reference—his claims to having performed improbable feats are entitled to credence, only when accompanied by such proofs as carry conviction. Mr. Case, along with many others, claims to have transmuted the chemical energy of carbon into electrical energy without heat. The only proof he offers is the exhibition of a fine sample of "volts." He asks us to believe without proof that the volts came from the oxidation of carbon. If Mr. Case obtained and measured as much as a single watt-second of electrical energy and proved that it came from the carbon, he did not publish the proof, nor state how much carbon was consumed in the operation.

Whenever the alchemist attempted to show that his gold was produced from the lead, his hand or his foot always slipped and he fell. Up to the present time the great host of philosophers who have attempted to show that "volts" (to say nothing of electrical energy) have been produced by the oxidation of carbon at low temperatures, have also failed.

The question raised does not seem to require discussion, being merely a question of fact. If carbon (the element carbon, not carbonaceous matter containing from 62 to 96 per cent. of carbon) has ever been oxidized at low temperatures with the evolution of energy in any form, it may be oxidized again in the same way. Both the carbon and the energy may be measured and all the facts and proofs may be stated so clearly that there will be no room for discussion. The world will gladly accept and welcome the results of any such demonstration.

If we accept all the statements made by Mr. Case as matters of fact, it would seem that carbon, instead of being difficult to oxidize at low temperatures, is one of the most easily oxidized of all substances, being oxidized by water, ferric salts and what not—even by reducing agents, such as the blood of animals!

As to the experiments described by Mr. Case in the paper to which he refers and those recently repeated by him in public, there can be no doubt that the reaction between sulphuric acid and potassium chlorate necessarily evolves energy. It is equally certain that a portion at least of this energy will be electrical, if a suitable arrangement of conductors is provided, especially if the reagents are separated by a porous partition and each placed in contact with an incorrodible electrode. In repeating the experiment described by Mr. Case, I obtained results which showed that the electromotive force was not due to the oxidation of the carbon. I used a cylindrical arc-light carbon as it came from the manufacturer. It was presumably nearly uniform in composition throughout its length. Yet when it was broken in halves and the two pieces were used as electrodes, a higher electromotive force was obtained than that obtained under the same conditions by substituting a piece of platinum for one piece of carbon. It was also found that a fresh piece of carbon was electro-positive to a piece of the same carbon that had stood a few minutes in the solution. This could be explained by the presence of a small trace of metallic iron in the carbon, also in other ways. The total energy obtained in my experiments was about $\frac{1}{1000}$ watt-second.

The statement of Mr. Case that numerous carbon compounds may be oxidized at low temperatures by various oxidizing agents and even by atmospheric oxygen, has not to my knowledge ever been questioned. My statements related only to the oxidation of carbon.

NATIONAL Electric Light CONVENTION.

The convention of the National Electric Light Convention, held at Niagara, June 8, 9 and 10, was the most successful in the history of this flourishing body, both in attendance and in the character of the papers read. The discussions were shorter than usual, but this was due rather to limitations of time on account of the number of papers on the programme, than to any lack of interest on the part of the audience. While the exhibits were not very extensive, this is to be ascribed partly to the severity of business conditions and partly to the fact that the electric lighting industry has reached such a stage that new developments are yearly becoming less frequent, and therefore there is no longer opportunity for the display of novelties that in the early days of the association were so plentiful and often epoch-making.

Undoubtedly a great measure of the success of the Niagara meeting was due to the retiring president, Mr. Frederick Nicholls, not only as its presiding officer, but through the interest he created in its object by his activity during the year. The several *ad interim* presidential reports issued showed that the association had an active spirit at its head, ceaselessly looking after its interests, which was also evident upon the publication of the excellent programme for the Niagara meeting. As a presiding officer Mr. Nicholls was courteous but firm, and rapid in the disposition of business, which perhaps accounts for the almost entire lack of perfunctory discussion at the Niagara meeting.

While the association is thus to be congratulated upon the excellent judgment displayed when electing a presiding officer last year, its choice of a president for the ensuing year has been no less happy. Its new president, Mr. Samuel Insull, is a worthy successor to perhaps the ablest president the association has thus far had, and under his guidance there is every assurance of a vigorous administration during the coming year.

Like Mr. Nicholls, Mr. Insull is a man of strong character united with an active disposition, and one who has made his mark in

each of the several important branches of the electrical industry in which he has labored. In the electric lighting field he is easily the foremost man in the United States, and consequently his election to the presidency was most appropriate. Mr. Insull is also president of the Association of Edison Illuminating Companies, and that two bodies formerly so antagonistic should now have the same presiding officer is a significant and welcome indication of a change of feeling that several years ago would have appeared impossible.

SAMUEL INSULL,
President National Electric Light Association.

One of the interesting events of the Niagara meeting was an evening lecture illustrated by stereopticon views, by Mr. L. B. Stillwell on "Niagara Power." The lecturer explained the various details of the generating plant of the Niagara Power Company, the Niagara-Buffalo transmission and dwelt on other matters of electrical interest at Niagara. The horse power of the Falls he stated to be 5,800,000, of which 4,000,000 could be practically utilized in the generation of commercial power. He illustrated the vast extent of the energy of Niagara by the statement that it is equivalent to that which could be produced in steam engines from 13,000,000 tons of coal per annum, the total annual production of the world being about 40,000,000 tons.

Of the papers read at the Niagara meeting abstracts are given below of all but two, which were read before the meeting in manuscript; these are the papers of Mr. C. F. Scott on "Rotaries for Transforming Alternating into Direct Current," and that of Mr. B. F. Lamme on "Polyphase Motors," abstracts of which will appear in a future issue.

Following are the officers elected for the ensuing year: President, Mr. Samuel Insull, Chicago; vice-presidents, Mr. A. M. Young, Waterbury, Conn., and Mr. Geo. R. Stetson, New Bedford, Mass.; executive committee, Messrs. Frederick Gilbert, Boston; W. Worth Bean, St. Joseph, Mich.; E. H. Stevens, Elizabeth, N. J., and W. M. Lea Walbank, Montreal.

In his presidential address Mr. Nicholls referred to the enormous developments at Niagara since the meeting of the association near-by in Buffalo five years ago. Then the possibilities of transmitting power in small units to moderate distances were discussed, while "to-day the problem is solved and innumerable installations are transmitting power in large quantities for long distances, and yet we have only crossed the threshold." He called attention to the fact that at present the association contains more active members than at any other period, while an unusually large balance of money appears on the books of the treasurer. Mr. Nicholls paid a flattering compliment to the electrical press, of which he said, "No other art, science, industry or profession has been so well and faithfully served by an enlightened and progressive technical press as our own, and who can estimate the fair share of credit justly their due for the part they have taken in aiding and advancing the introduction of electricity in its many and varied applications?" The business-like management under the late administration was illustrated by the announcement in the address that although several delightful and interesting excursions had been arranged for, it was thought best, while taking advantage of the same, to pay for the privileges offered rather than tax the courtesy of the transportation and other companies by accepting them gratis. In the desire not to subordinate the real interests of the meeting, no favors were accepted nor asked from other than from the electric power companies and several of the manufacturing establishments using electric power for the operation of their works.

The only discussion of note in open meeting, aside from that on the papers read, was on the topic of "Theft of Current and how to Prevent It." From the remarks it appeared that the theft of electric current is not so rare as might be supposed, in most instances through tampering with the meter. In one case related a saloon-keeper threw grappling hooks over the wires of an Edison circuit and thus lighted his saloon for several months. A committee of three was appointed to prepare a report on the subject and draft a bill with a view to having it introduced in the legislatures of the various states in order to make the law uniform throughout the country.

REPORT OF THE COMMITTEE ON DATA.

The usually extensive table does not accompany the report of the committee on data this year, but instead is a lengthy report by Mr. F. R. Lowe, in which an examination is made of the various factors affecting the economical generation of steam power, together with a table giving results of the examination of data of fourteen central stations from which reliable returns were obtained.

Figures are given to show that, as far as boilers are concerned, wide differences in the demand at different periods do not seriously affect the economy of generation of steam. In one instance quoted, a battery of boilers was forced to nearly double its rated capacity with a decrease of only 6 per cent. in its efficiency, and the same battery could probably be diminished one-third in capacity with still less impairment.

Figures are also given to show that boilers laid off with banked fires consume an average of ½ lb. of coal per square foot of grate, per hour, or 4.17 per cent. of that burned while running at 12 lbs. per square foot in the same time. When a boiler runs sixteen hours a day at an average rate of 12 lbs. of coal per square foot of grate per hour, and stands the other eight with a consumption of ½ lb. per square foot of grate per hour, the coal used while idle will be 2.04 per cent. of the whole.

It is suggested that an economical advantage may arise from using two grades of coal when running with widely varying loads—a good steaming coal, with which the boilers can be forced at overload, and a cheap small coal, which can be used to advantage on the otherwise sparsely-covered grate surface when the load is below the average.

The report considers that the importance of the impairment of efficiency from overload has been overestimated. In one instance (that of an engine plant of low efficiency), it is stated that if all the engines in the station run all the time at one-half load, the impairment would be less than 33 per cent., and if they were run at 50 per cent. overload, the impairment would be only 8 per cent.

The report considers that the loss by leakage is greater than is generally supposed. At one of the stations visited the leakage was about 2000 lbs. per hour in the winter time, and in the summer with one-half the engines, two-thirds the boilers and all the heaters shut off, it was about 500 lbs. per hour. In another case the leakage amounted to 3500 lbs. per hour. The total loss from

CENTRAL STATION DATA.

No.	Hours Run.	Results.		Efficiency per cent.	Percentage of Coal Used for						
		Lbs. coal per K.W. hour.	Watt hours per lb. coal.		Engines.	Conversion.	Leakage.	Radiation.	Auxiliaries.	Boilers.	Unassigned.
1	24	8.30	120.5	24.09	20.95	.24	......	......	......	19 91	34.79
2	6-12	6.24	160.3	32.05	27.30	3.63	......	......	......	26.98	10.04
3	24	3.71	269.5	53.91	9 03	......	11.63	......	......	19.98	5.45
4	24	4.56	219.7	43 86	5 88	2.13	< −12	—>	......	25.00	23.11
5	23	8.69	115 1	23.01	24.97	6 95	......	......	......	.4	32.66
6	24	3.82	262.	52.10	8.80	5.03	......	4 00	......	......	30.07
7	24	8.91	112.2	22.45	22.56	5.50	......	......	......	38 60	10.89
8	14-20 Av 17	8 67	115.3	23.07	......	......	......	......	6.04	39.60	31.28
9	24	6.64	150.6	30.12	30.12	21.50	......	......	......	1.70	17.56
10	24	8.62	116.	23.20	24.12	7.5	......	......	......	1.50	43 67
11	24	10.13	98.7	19 74	9.27	......	......	......	......	42.50	28.49
12	24	7.45	134 3	26.85	38.22	......	......	......	......	−13.60	48.53
13	12	7.33	136.5	27.29	11.45	......	......	......	......	25.00	36.26
14	24	5.68	176 2	35.21	10.64	1.07	......	......	5 30	10.00	37.77

condensation may be shown by actually trying the experiment of keeping the plant under steam with boiler pressure, with the engines turned off but not running, and weighing the amount of coal burned per hour to keep up the pressure. It is believed that the result will show that in many plants a surprisingly large percentage of the total amount of coal burned is thus wasted.

As the auxiliaries use from 75 to 200 lbs. of steam per indicated HP, it is considered advisable to run these by electric motors. At a cost of generation of, say, 20 lbs. of steam per HP and a loss of 50 per cent. in electrical transmission and transformation, at the point of application this will amount to 40 lbs. of steam per effective HP against 75 to 200 lbs. required by the steam motors displaced, to say nothing of the reduction to be expected in radiation and leakage losses.

The report considers that 500 watt-hours per pound of coal should be taken as the highest standard of efficiency, this corresponding to 13 lbs. of steam per indicated HP with a difference 15 per cent. between the indicated and electrical HP and an evaporation of 10 lbs. of water per pound of coal. The foregoing table contains data compiled from stations from which reliable information was procurable. The column headed "efficiency" shows the percentage of coal actually used if the above standard were achieved; under "conversion" is given the percentage of the coal consumed by reason of electrical losses exceeding the standard assumed.

REPORT OF COMMITTEE ON STANDARD CANDLE POWER OF INCANDESCENT LAMPS.

The report of this committee, after stating the problem that was presented to it, and giving the result of the work of the American Institute of Electrical Engineers in laying down a definite basis upon which to construct a commercial system of testing, explains and discusses in detail the considerations which have guided it in the achievement of such a system. The final recommendations of the committee are as follows:

First: That the standard 16-CP incandescent lamp shall be a lamp which, when measured while rotated at about the rate of 180 r. p. m., with the axis of its filament inclined 45 degs. to a vertical plane, shall give not less than 14½ and not more than 17½ CP, and that every ten lamps shall average between 15 and 17 CP.

Second: That the committee shall be empowered to make suitable provision for the production of secondary standards, and to request the co-operation of the American Institute of Electrical Engineers in the formation of a non-partisan committee to supervise and certify the standardization of such lamps.

Third: That the secretary be directed to undertake, under the direction of the committee, the procuring of lamps for standardization, their distribution when standardized, and the preparation and distribution of the specifications of the committee for a standard form of photometer, and a standard method of employing it.

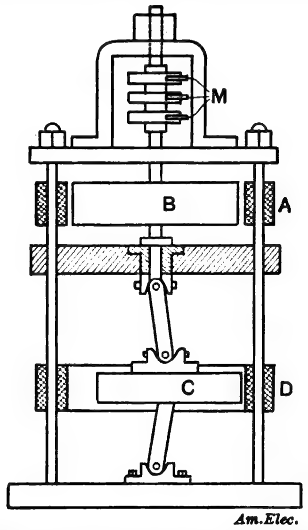
REPORT OF THE COMMITTEE ON SAFE WIRING.

Capt. Brophy presented the report of the Committee on Safe Wiring, in which the history of its labors is resumed, showing the very great difficulties that had to be overcome in reaching the very satisfactory result finally arrived at. At the final meeting of the conference, which included representatives of all the various professional bodies, and at which the underwriters were well represented, an agreement as to rules was finally arrived at. Capt. Brophy reported that the new set of rules is to be called the "National Electrical Code"; that the National Board of Fire Underwriters in printing the code should give on the inside of the cover due credit to the National Conference for its work, and place upon the cover the names of all the associations forming the National Conference as fast as these bodies gave their endorsement to the code. On June 5 a meeting of the Code Committee of the Conference, to whom was left authority for final action, met at Boston and the code previously agreed upon was unanimously adopted. Upon motion of Mr. Carnes, the report of Capt. Brophy and the code recommended were unanimously adopted, and thus the National Electric Light Company, which was the first to adopt a national standard code of rules, is the first to approve and adopt the new codification.

FREQUENCY TRANSFORMATION.

In a paper read by Lieut. F. Jarvis Patten, an apparatus for the transformation of frequencies was described, the principle of which is illustrated in the accompanying sketch. *A* and *B* are toothed iron rings with Gramme windings, supplied with polyphased alternating currents, which set up a rotary field in each ring.

Within the lower ring is an iron disk which, when the ring is energized, is made by



PATTEN FREQUENCY TRANSFORMER.

the rotary field to travel on the inner periphery of the ring. As this disk has a diameter less than that of the ring inside of which it rolls, its axis will have a rate of rotation different from that of the magnetic field, making a revolution in less time than the field, the difference depending upon the relative diameters of the disk and ring.

Within the upper ring is the secondary of a transformer, of which the ring is the primary. Were this secondary or armature to remain stationary, there would be induced in it a current of the same frequency as the primary. By being given, however, a motion of rotation through its connection with the iron disk, this frequency is altered, becoming equal to the difference of the original frequency and the rate of rotation of the armature, or to their sum, according as it may be desired to decrease or increase the rate of frequency. The lower ring is supplied with current from the armature collector rings, *M*.

DAYLIGHT WORK OF CENTRAL STATIONS.

A paper by Mr. T. C. Martin with the above title urges the desirability of central stations obtaining a daylight load. A considerable portion of the paper is a plea for electric heating. The author points out that eleven years ago it was considered that electric power had not a ghost of a show; to-day electric heating stands just where electric power did ten years ago and, he believes it offers central station men an opportunity of the best kind for the introduction of apparatus that must serve as a large customer for current at all seasons of the year.

MUNICIPAL LIGHTING.

In a paper with the above title, Mr. W. Worth Bean most vigorously denounces municipal ownership, the authors and promoters of which, he states, are either visionary theorists or unscrupulous politicians hoping to secure plums for themselves and their henchmen. Municipal ownership he denounces as contrary to the spirit of public institutions and in conflict with the Declaration of Independence, and a source of danger to the commonwealth in that it offers a great opportunity for fraud. It is unjust to the electrical plant now on the field, as it must either compete with a municipal plant instituted or sell out. As one cannot hope to dispose of a plant that has depreciated 50 to 75 per cent. without great loss, he is therefore compelled to continue in the business with his former heaviest customer now his strongest competitor, with the knowledge that there is room for but one paying plant in the place. Such conduct on the part of the city amounts to the direct confiscation of property, and involves a lack of faith through obtaining the installation of an effective service for use without profit by holding out promises for future gains, which are then not permitted to be realized. The entirely unreliable and misleading reports of municipal plants were referred to, and it was suggested that every member of the National Electric Light Association, and the manager of every central station shall, constitute himself into a committee of one to get reliable data concerning municipal ownership and present it in a proper form to the thinking public of the country, it being believed that after a free and thorough examination of these figures by companies and taxpayers, the question of municipal ownership will be effectually settled.

In the discussion of Mr. Bean's paper, Mr. Dougherty, of Madison, Wis., strongly recommended the employment of experts to determine the true cost of lighting from municipal plants. Mr. Beggs endorsed this recommendation, stating that there is no use to which the association could devote to better advantage a part of its funds than in the payment of a competent expert to obtain such data.

ESTABLISHMENT OF A BASE PRICE FOR CURRENT.

In a paper read by Lieut. J. B. Cahoon, the question is discussed of a rational basis for determining the price to be charged for electric lighting on a flat rate. A careful analysis of the prices paid per KW-hour in incandescent lighting in different sections of the country, seems to show that in many instances the prices charged are based upon what somebody else has charged rather than what ought to be charged in view of the cost of the principal item entering into the operating expenses at each particular place. The two most important factors entering into operating expenses are wages and coal; it is assumed that bituminous coal with an evaporation power of 12 and costing $2 per ton delivered at the bunkers, enters as a factor at practically 25 per cent. of the operating expenses of the company, said operating expenses including every expense attendant upon the production and distribution of the current and the administration of the company, and also including taxes and insurance, but not expenditures for wiring of buildings or fixed charges. If twenty cents per KW-hour is fixed upon as the price which consumers should pay on the above basis, the actual ratio of the cost of coal to the entire operating expenses should be determined, and the price of twenty cents per KW-hour correspondingly increased or diminished.

For example, if the operating expenses were $40,000 and the cost of coal $10,000 at $2 per ton, the cost of coal is 25 per cent. of the operating expenses. By assuming other costs of coal, a curve may be laid down showing the effective variations in the price of coal, other expenses remaining the same. In this manner it is found that if the price of coal is $1 per ton and other expenses remain the same, the coal will be 14.28 per cent. of the total operating expenses, while at $4 per ton, it will be 40 per cent. Having fixed upon twenty cents per KW-hour as the price which consumers should pay on a basis of coal of evaporative power 12 and a price of $2 per ton, then if the same quality of coal can be obtained for $1 per ton, the price per KW-hour would be $20 \times (1 - .1428) = 17.144$; and if the price of coal be doubled or is $4 per ton, the price per KW-hour would be $20 \times (1 + .40) = 28$ cents.

A portion of the paper read by Lieut. Cahoon is devoted to the subject of central station forms, of which a number are given in the paper. The forms recommended enable the station manager to readily ascertain whether the business for the month as a whole has been conducted on a profitable basis or at a loss; whether there has been an increase in business; whether too much has been expended in one direction and not enough in another—in fact, enabling him in a brief space of time to analyze the business for the entire month in such a way as to give him the information that he needs in order that he may intelligently conduct the business to a succesful issue.

In the discussion of Mr. Cahoon's paper, Mr. John I. Beggs said that in a new station being built by his company, he hoped to generate electrical energy at one-third the cost in the present station. He recommended the use of a uniform set of blanks in order that the results of operation in different stations may be compared, the larger Edison illuminating companies having adopted this practice.

THE INDUCTION FACTOR.

Prof. C. A. Carus Wilson in a paper entitled "The Induction Factor, or a New Basis of Dynamo Calculation and Classification," shows how certain dynamo and motor calculations may be abridged by the introduction of a torque factor. Taking the usual expression* for torque, $t = 1.41\,p\,C\,A\,N\,10^{-8}$ (where A is the number of inductors on the surface of the armature, N the lines of force per pole, p, the number of poles and C, the current), this can be written $t = 1.41\,C \times p\,A\,N\,10^{-8}$; as the second factor in the right hand term is a constant for any machine, this may be represented by M, and the expression for torque reduces to $t = 1.41\,C\,M$. As the E. M. F. generated in an armature is represented by the formula, $E = p\,A\,N\,n\,10^{-8}$, where n are the revolutions, it will be seen that $M = \frac{E}{n}$. Following are some of the applications of the formula to practical cases:

1°. To find the torque on the shaft of a direct-coupled generator, the current being 300 amperes, the speed 400 r. p. m. ($6\frac{2}{3}$ per second), and the voltage 120: Dividing the volts by the revolutions we have $M = 18$; multiplying by 1.41 and the current we have $t = 1.41 \times 300 \times 18 = 7610$ in.-lbs. For a more accurate result the volts lost in the armature should be added to the reading of the voltmeter.

2°. To find the pull on a belt driving a railway generator, the pulley having a diameter of 40 ins. (20 ins. radius), the speed being 440 r. p. m. ($7\frac{1}{3}$ per second), the voltage 550, and the current 400 amperes: In this case, $M = 550 \div 6\frac{2}{3} = 75$; $t = 75 \times 1.41 \times 400 = 42{,}200$ in.= lbs.; and the pull at 20 ins. radius will be $42{,}200 \div 20 = 2{,}110$ lbs. If the internal drop is 15 volts (corresponding to an armature resistance of .0375 ohm and a current of 400 amperes), M would be $565 \div 6\frac{2}{3} = 76$, and the actual pull would be 2166 lbs.

M being equal to $\frac{E}{n}$, $CM = \frac{CE}{n}$ will represent the work of a dynamo or motor per second; the author calls CM the force factor of the dynamo, which can be used in the comparison of dynamos independent of speed.

3°. If the induction factor of a dynamo is 5 and the maximum current 100 amperes, $CM = 500$ and the rate of working at 25 r. p. s. is 12.5 KW.

4°. A 4-pole railway generator with the armature parallel-connected (making $p = 1$) has an induction factor of 77; the force factor for 600 amperes is $600 \times 77 = 46{,}200$; the output at 450 r. p. m. (7.5 r. p. s.) is, therefore, $46{,}200 \times 7.5 = 346$ KW.

The remainder of the paper considers the application of the induction and force factors in designing.

The use of the induction factor is recommended for dynamo classification. As an illustra ion, two machines of the same speed and output have induction factors of 5 and 50 respectively. This indicates that if they are to run at equal speeds and give the same KW output, the current delivered by one will be ten times that delivered by the other; and if they are to be run as motors at the same speed and HP output, one must run on a line voltage ten times that of the other.

NIAGARA POWER TRANSMISSION LINE.

Mr. J. G. White, of the White-Crosby Company, read a paper on the Niagara transmission line, which was constructed by his company. It was originally intended that the poles of the Niagara-Buffalo lines should be of iron, but the specification was afterwards changed and white-cedar poles designated. The length of the pole lines is 27 miles, and the line consists of three conductors, each having 350,000 circ. mils, and composed of nineteen strands, each conductor weighing nearly 6000 lbs. per mile. The poles are spaced 75 ft. apart on straight, and closer on curved, parts of the route. Thirty-five-foot poles were used on a part of the company's right-of-way, but many 50-ft., and even a few 65-ft., poles were required to avoid obstructions in crossing roads and highways. The 50-ft. poles are 8 ins. in diameter at the top and 18 ins. at the butt, 8 ft. being in the ground.

Considerable difficulty was found in obtaining insulators of necessary electrical strength. It was considered that a testing strain of 40,000 volts is a minimum safe limit for a regular strain of 10,000 volts, and is a test which any economical, good, well vitrified insulator of ordinary design will pass. The insulators were tested by placing them in a shallow iron pan in lots of about twenty, the bottom of the pan being covered with an inch or two of water containing a little salt. A small quantity of the same brine was poured into the pin hole of each insulator, and into this was dipped a small piece of metal connecting to one side of the testing circuit, the other end being connected to the pan containing the insulators. The 40,000-volt circuit was then closed, and if the insulator was weak, this was manifested by a series of sparks through the punctured porcelain.

In the experiments with insulators, it was noted that the insulating strength of porcelain depends almost entirely on the thoroughness of its vitrification and very little on its thickness, a thin china tea-cup having successfully withstood a pressure of 60,000 volts, while a coarse piece of porcelain, 2 ins. thick, was readily pierced by 20,000 volts. Mr. White, therefore, concludes that it is practically unnecessary to test electrically any insulator which, when broken, will not pass a good absorption test, using red ink or other fluid. Glass insulators were found efficient with any voltage that can be used, the limit of such voltage being the arcing distance around the insulator. The objection to using glass insulators has been due to the difficulty of getting a well annealed and mechanically

* This expression is deduced as follows: Multiplying the expression for E. M. F. per revolution, $E = p\,n\,A\,N\,10^{-8}$ by C, we have an expression for watts, n being the revolutions per second; multiplying this by 550 and dividing by 746 gives foot-pounds and this multiplied by 12 gives inch-pounds. In terms of torque the energy is $2\pi\,n\,t$ (in inch-pounds); equating this with above and reducing, we have $t = 1.41\,p\,C\,A\,N\,10^{-8}$.

strong insulator of such massive design as is needed for high-tension work, as well as to the hygroscopic property of glass, which is not shared by porcelain. Mr. White considers it reasonable to expect that the use of glass insulators for high voltage lines will greatly increase with improved manufacture. Mr. White stated that the reason why the entire Niagara-Buffalo line was not placed underground was on account of the cost, which would have been three times greater than that of an overhead line.

In answer to a question by Mr. Seely, Mr. White stated that insulators could be replaced on the line without shutting down. This is done by mounting a ladder on a stool supported by four large porcelain insulators, the wire being lifted on top of another insulator mounted on a long stick and then transferred to the new insulator when in place. The static charge will give a disagreeable shock if care be not taken. The wires are not placed at the corners of a triangle as originally intended; the line is divided into six sections, and the three wires shifted relatively to each other in each secion, thus reducing the reactance. Of the insulators that stood the 40,000-volt test, not a single one has broken down in place. The line at present is protected from lightning by two barbed-fence wires, one on the peak of the pole and the other on the outer cross-arm, each grounded every fifth pole; it is intended to put another on the other side of the cross-arm. Mr. Dana Greene considered that the most serious question involved in overhead construction was the danger from lightning, and that there will always be more or less risk from lightning until the wire is put underground. In answer to a question whether lightning arresters on a line carrying 1000 HP would carry a lightning discharge and at the same time interrupt the dynamo circuit, Mr. Greene replied that he did not think any company would guarantee such a device. Mr. Beggs doubted if the Niagara power could compete with an efficient steam plant in a locality 50 miles distant; Mr. White replied that but in few cases would such a lengthy transmission be feasible. Mr. Steinmetz objected to generalizations on the subject, as the feasibility depends upon the price of competing power, whether the load is large, the number of hours' use daily, and other conditions. Mr. Walbank describes the Lachine-Montreal pole line, the cost of which was $92,000 for 30,000 ft., whereas an underground line would cost $300,000. The poles are made by cutting channel irons diagonally, and then riveting the reverse ends—making the pole 8 ins. at the top and 20 ins. at the bottom. The poles are 108 ft. apart, about 30 ft. high with 7 ft. embedded in the ground in concrete.

PROFITABLE EXTENSION OF ELECTRICITY SUPPLY STATIONS.

Mr. Arthur Wright, the electrical engineer of the Brighton, England, central station, in a paper read before the convention dealt with the subject of a rational system of charging for electric lighting, and explained the Wright maximum demand system, which has been so successfully used at Brighton and other cities in Great Britain.

The main basis of the Wright system of charges is that all consumers should be a source of profit, which policy, the author believes, will place electrical supply on a plane of competition with gas in price, and enormously extend the sale of current. The idea that large consumers' bills necessarily mean large profits he considers should be dismissed, as very frequently the reverse is the case; by a proper system of charges, a class of small consumers can be reached that will not only be extremely profitable, but much more so than many of the larger ones. The readiest of all means of reducing the cost of supplying electricity is such an adjustment of the charges as to offer great inducements to profit-yielding consumers, and insure that the unprofitable ones shall be charged at as high a rate as is possible or expedient. In other words, a system of charges that will broaden out the average load curve of the station and thus increase the usefulness of the investment, the question of charges, indeed, being of greater importance than engineering economies. It is sound commercial practice to encourage the profitable even at the risk of losing some of the profitless business, and under no circumstances should the supply of short-hour customers involve a loss to the supply station or increase the charge to the more profitable classes.

With the usual system of charges it will be found that many consumers pay two lighting bills—one for electricity, which by reason of the high uniform price is only used in short-hour lamps in show places; and another for gas or other illuminant which is used in long-hour burners. Yet the actual conditions under which these different lights are produced and supplied favor quite the reverse order of things. Discounts on the consumption per lamp installed have the reverse effect of that intended, as a consumer usually puts in only those lamps that he can use freely in order to obtain the benefit of the discount. The tendency of this is to contract the load curve and drive up the peak and to discriminate against hotels and private residences—which are exceptionally good users of light with respect to the load curve—and also prevent large business establishments from wiring their entire premises, although probably the lights used in the upper parts of the building and staircase would be used when many on the lower floor are extinguished. Other objections are the difficulty of practically determining the connected load, and the unwisdom and expense of visits of inspection to private houses, hotels, etc., which the flat system requires.

The system of giving different tariffs for motors and lamps is condemned, as it implies that the consumer who requires the use of the station plant at night should be debited with the whole of the fixed charges incident to keeping this plant ready, although the same plant may be equally used in the day-time to supply another consumer's motor.

In the opinion of Mr. Wright, one of the most profitable fields for extension lies in the displacement of isolated plants, and he maintains that by a judicious system of charges isolated plants may be induced to change over and take their current from street mains. Such plants are generally installed where the demand for electricity is of a lengthy nature, and by the application of an equitable sliding scale this very profitable business can be brought to the supply station. At Brighton, England, since the adoption of the Wright system of charges, the business formerly handled by several isolated plants has been turned over to street mains, and not a single new isolated plant put in.

The importance of encouraging the installation of lamps to be used at different times day and night is dwelt upon; it is shown that at Brighton, where the use of electricity is very evenly divided between residences and stores, the diversity factor is less than 1.5; that is, if all the consumers were to receive their ordinary supply at the same time, the generating plant of the station would have to be increased very nearly 50 per cent.

The direction in which new additional capital can best be spent is rather in running mains in all parts of the town in which artificial light is used in the evening, even in the poorer quarters, than in spending money on coal-saving refinements or running large mains for districts occupied by large early-closing stores or the mansions of the wealthy. The author especially urges the true economy of a liberal supply of distributing mains, which can be made to serve the double purpose of supplying the street lamps as well as the general public, and he questions the wisdom of running special mains and systems for the sole supply of public street lamps.

The Wright system of charges consists in charging to each customer first, a part of the fixed charges proportionate to the maximum demand which he makes on the plant; second, the cost of producing the electrical energy he uses, increased by an amount necessary to pay dividends and lay aside for depreciation; that is, a high initial rate of charge per KW-hour or lamp hour to each consumer to meet the annual fixed charges of the plant, this being based upon his maximum demand, and then a substantially reduced rate for subsequent consumption, the system thus forming the basis of a perfectly equitable tariff applicable to all stations and conditions of supply.

One result of the adoption of this system of charges at Brighton has been to enormously increase the sales per maximum KW-load on the plant, and even with coal costing the high price that it does at Brighton ($5 per ton), an improvement of the load factor of only 3 per cent. has the same effect in reducing the total cost of producing electricity as if the coal bill had been reduced 15 per cent.

To illustrate how impossible it is for electricity to be supplied at a uniform rate of charge at so low a price as it profitably can be on an equitable sliding scale to lamps used in the average house, it is noted that in 1896, to produce the same amount of profit, the uniform charge for a four-hour class of consumers must have been 9.3 cents per KW-hour, as against 7.5 cents, or an increased charge of 25 per cent. In the case of lamps burned an average of six hours per day, the necessary uniform charge would have been 46 per cent. higher; and in the case of lamps running ten hours per day, the uniform charge must have been 70 per cent. dearer than on the system of equal profits. On the other hand, the one-hour consumer on the uniform system would have

been charged 9.3 cents, as against the proper charge of 17.86 cents per KW-hour, and as 15 cents would have been the actual cost of supplying him, the effect would be a loss no less than 6 cents for every KW-hour so sold.

In the discussion of Mr. Wright's paper the author said that the least price for a KW-hour at Brighton is 14 cents, and 3 cents for every additional hour. The average income per KW-hour during 1897 will be about 6 cents. The most favored customer is paying 3½ cents per KW-hour. Mr. Beggs said he believed in a flat rate with discounts, and thought that the Brighton system is unjust to the small consumer, and that the price of gas should never be cut under. Mr. Insull stated that his company used what is practically the Wright system of charges, and that it is necessary to cut under the price of gas to compete with isolated plants, going as low as 4½ cents per KW-hour for this purpose. He differed with Mr Beggs that a system of discounts solves the problem, and as an illustration gave the case of the largest building in Chicago which is not profitable at 20 cents per KW-hour, while a certain comparatively small store paying about the same total amount per year is profitable at 6 cents. Mr. Insull and Mr. Stetson heartily approved of the Wright system. Mr. Ferguson criticised it on account of making no distinction in regard to the time of day a load is on. In reply to Mr. Ferguson, Mr. Wright said that the fixed charges were an entire charge against the whole investment and not an hourly, daily or monthly charge; that if one customer used the plant only before a given hour and another only after that hour, each should pay the full investment charge.

RECENT PROGRESS IN ARC LIGHTING.

In a paper with the above title, Prof. Elihu Thomson presented an admirable review of the present state of arc lighting. Professor Thomson considers that the immediate future of the series arc lighting system appears to be in the development of large dynamos up to, say, 300 arc lights each, running at such speeds that one or a pair may be easily coupled directly to the shaft of a moderately high-speed engine. The use of a regulated constant current on the series system, besides giving a simple system as to wiring, etc., is seemingly best adapted to the use of the cheaper carbons. For extended districts the series arc lighting system is still likely to hold its own, but displacement by constant-potential arcs and enclosed arcs on constant-potential circuits will doubtless continue in cities supplied by underground low-pressure continuous-currents systems.

Attention is directed to the fact that a dynamo well adapted to a differential arc lamp is not necessarily adapted to shunt-feed lamps, since the latter lamps require a more rapid droop in the characteristic than the differentials; on the other hand, any circuit of pure shunt-feed lamps will take differential lamps without difficulty when adjusted for the same current, but if the current fluctuates in value and there be but few differential lamps on the circuit, these are the ones to suffer, since the shunt-feed lamps are sensitive to current variations, and the latter are not.

Two points should be observed in the design of arc-lamp mechanisms; first, the variation of pull for a given variation of current in the magnets controlling the lamp should be as great as possible; and second, there should be as little as possible variation in the force required to feed or recover from feeding.

In regard to pulsating currents, such as are produced by rectifiers, Prof. Thomson thinks that under proper working conditions there should be a certain field for the use of rectifiers in the United States as well as in England, where Ferranti for some time past has used them. The rectifiers have the one great advantage of permitting the generation of current in a station by means of large direct-connected dynamos, of which but a portion of the capacity need be used to feed rectifiers for supplying arc lamps; moreover, the efficiency of the rectifiers is high, and may easily be made over 90 per cent. The apparatus is not of excessive size for a given output; a simple commutator revolved by a properly constructed synchronous motor with arc-machine brushes and air blast, complete the machine. When two-phase or three-phase currents are to be rectified, there will be at least two or three transformers giving a current of constant value, one for each phase, and the secondary current may be combined through commutators resembling those of the Brush arc dynamo for the two-phase, and the Thomson-Houston for the three-phase; in such cases the resulting rectified current is much more nearly a steady or smooth current, and not so much a pulsating current as that derived from a single-phase generator.

In regard to constant-potential lamps, among the advantages are the relatively low tension and absence of danger, the facility of installation and ease in metering the supply. The loss of energy in the distribution may, at full load on the lines and moderate distances from the supply stations be, say, 10 per cent. or more, chargeable chiefly to feeder drop, and about 15 to 20 per cent. in dead resistance in the lamp branch. This loss of, say, 25 per cent. while much greater than the percentage of loss on the series system, is yet largely, if not wholly, made up by the superior efficiency of constant-potential, low-pressure generators of large capacity over arc machines, and by the high engine efficiency which may readily be obtained in driving large generators, especially when working with economical loads. On the other hand, a better and more expensive carbon will be required for constant-potential work than for plain series arc lighting.

Prof. Thomson does not consider that constant-potential lamps with sufficiently sensitive mechanism are open to the charge that one will rob the other when two or more are placed in series. The use of a resistance in series with constant-potential lamps is inevitable in order to give stability to the current. A serious objection to constant-potential series lamps, especially those of 220 to 500-volt circuits, is the inability to cut off the lamp or lamps in a branch without substituting an equivalent resistance.

Two ways are described for working alternating-current arcs in a series; either directly or through the intermediary of transformers feeding the lamps with a current of constant value, or with a variation not over 15 per cent. from light to full load. In the first-named case, only the ordinary series magnet is required, but there must be a reactance in shunt to replace a lamp cut out of circuit; another way of accomplishing even a better result, but which requires a shunt or differential magnet to be used, is to substitute by means of a special switch a proper reactance in place of the lamp which is to be cut out, and also to cause the lamp, on failure to feed, to cut out and substitute for itself this reactance. Whenever reactance is thus used with arc lamps, the waste of energy is very small, but a large number would interfere with the proper regulation of potential at the generator on account of the load of inductance they introduce. Neither of the above systems when working have yet reached a decided commercial importance.

The other method is by means of a transformer, so constructed as to have a considerable magnetic leakage between the primary and secondary coils, thus enabling a current approximately constant in value to be produced, whether the circuit has on it a full load of lamps or is short-circuited; in this case the regulation of the lamp must be by a shunt magnet, and the shunt reactance need not be used, as the current has a constant value and regulates for the number of lamps in circuit.

For enclosed arc lamps the carbons should be the very highest grade as to purity and uniformity of shape, and the present success of such lamps is the outcome of the ability to now secure such carbons. The high voltage of this type is a positive advantage for constant-potential circuits, as it reduces the amount of compensating resistance in such circuits. The mechanism is naturally very simple, a simple series magnet sufficing, since the lamp regulates entirely by the value of the current in its circuit. There is required, however, even with a lamp so apparently simple in itself, great care in proportioning the parts and of the relative actions to secure the best results. A compensating resistance is necessary in such arcs as well as open arcs.

In some experiments made under the direction of Prof. Thomson, it was shown that with two open arcs in series, the amount of voltage necessary to maintain the arc varied from 104 to 108 volts, or with 42 volts at the arc and 6 amperes, 98 volts on the line were required; with an enclosed arc lamp the voltage varied from 88 to 100, the former corresponding to 7 amperes and the latter to 3.2 amperes. The tests showed that a certain voltage, as a minimum, is absolutely necessary in working arc lamps on constant-potential lines, whether they be open arcs or enclosed arcs; thus two 45-volt arcs in series with ordinary carbons cannot be safely worked below 110 volts on the line with resistance in series with them, and more than this voltage should, of course, be maintained for safety of the service. With a cored carbon the voltage of the arcs may be safely reduced somewhat. It would also appear that with either open or enclosed arcs, and a current of, say, from 5 to 10 amperes, the steadying resistance should be such as to cause a drop in it of 15 or 20 volts.

The musical note of an alternating arc is due to the fact that the arc is extinguished at

each alternation of the current; this extinguishment also gives rise to difficulty in starting the arcs without their chattering up to the time when the carbons get strongly heated. In starting the arc, the carbons must be separated very slowly, while a large current should flow so as to strongly heat the ends, or a higher potential than that to be used in running the lamp after starting must be applied at first. Another way is to employ a resistance or reactance in circuit with the arc lamp; this changes the character of the potential of the lamp current, which, in fact, begins to approach in a measure constant-current supply. This expedient requires an increase in the potential of the line and involves a loss of energy. It is found not to be practicable to run alternating arc lamps on circuits much below 40 cycles.

The efficiency of an alternating arc lamp depends upon the form of the wave of current, being highest as the current curve flattens out; Prof. Thomson is of the opinion that with very flat top waves the limit of periodicity would be found far below 40 cycles. Soft carbons are best suited to alternating-current arcs and they are frequently cored.

An alternating-current arc under no circumstances can give as much light for a given expenditure of energy as a continuous-current arc, for the reason that both carbon points being equally heated, the temperature cannot be as high as that of the single crater of a continuous-current arc, and the light efficiency depends upon the temperature of the radiating source. The arc in the ordinary alternating-current lamp appears to be stable even when the connection is made across constant-potential mains without resistance or reactance in the branch as a check upon the current, which fact tends to neutralize the lower efficiency in the alternating arc, there being no dead resistance loss involved. Prof. Thomson considers that it is too early to predict what part the enclosed alternating arc may play in the future art of arc lighting, but it probably will find a considerable application.

Data are given concerning recent innumerable tests of different types of arcs and arc lamps under conditions resembling those of practice with a view to ascertaining their lighting values. It was found that the larger the current used with an arc with normal voltage, the more efficient is the light production. With the same brand of hard carbon, it is found that whereas with 10 amperes and 48 volts the consumption of energy was 1.2 watts for each spherical candle power, with arcs at the same voltage and 7 amperes it requires 1.4 watts. The cored upper carbon appears to raise the efficiency moderately, probably on account of the less voltage of the arc. A clear-glass globe absorbs 10 to 12 per cent. of the light, while alabaster and opal globes absorb from 45 to 65, according to the thickness and the specific absorptive power on the glass. With enclosed arc lamps measurements made on a run of 102 hours with 4¾-ampere lamps, showed a mean spherical candle power for an expenditure of 1.94 watts in the arc. A 25-volt, 16-ampere naked, alternating-current arc used per mean spherical candle power, 1.49 watts, or 1.12 watts for the mean useful candle power below the horizontal, which was reduced to .8 to .9 watts when the reflector above the arc was used. The energy required by an alternating enclosed-current arc per mean spherical candle power under the best conditions was about 2 watts, increasing toward the end of the run. The apparent advantage in economy of the continuous-current enclosed arc over that with alternating current is in a large measure neutralized by the fact of the former requiring a dead resistance instead of reactance in circuit to give stability to the current. Prof. Thomson adds that it must still be confessed that in the end the luminous yield is but little better than that obtained in incandescent lighting, but that the whiteness of the light and the daylight effect, especially now that frequent trimming and attention to the lamp are not needed, may be a sufficient reason for the large introduction of enclosed arcs.

In referring to the origin of the enclosed arc lamp Prof. Thomson stated this type is, broadly speaking, an outcome of the ability to secure very nearly pure carbons. He made some experiments in this field in 1879 and states that for many years after that date there were not to be found carbons sufficiently pure to insure a deposition slight enough to work an enclosed arc practically. In a letter to the AMERICAN ELECTRICIAN, Prof. L. B. Marks contests the statement that the success of the enclosed arc is merely due to ability to secure very nearly pure carbons. The history of the development of the enclosed arc, Prof. Marks says, is the record of a succession of failures up to 1894, when, as a result of his work, the first successful enclosed arc lamps were put on the market. The commercial enclosed arc lamp, he states, is only three years old, and of the thirty odd thousand enclosed arcs now in successful daily operation in this country, nine-tenths have been installed within the past two years. Prof. Marks does not believe that this phenomenal growth is due to the discovery of a pure carbon, as practically the same grade of enclosed arc carbon now extensively used was to be found in the open market at least five years before the advent of the successful enclosed arc lamp. While the idea of burning an arc in a practically closed and relatively small glass chamber, Prof. Marks agrees, is quite old, the idea of operating a high-potential arc within an enclosure and maintaining the arc with a small expenditure of current is new. Although years before he had used very nearly pure carbons in his investigations with enclosed arcs, still the experiments resulted in failure after failure until the idea of the high-potential arc was evolved by him, which method of operation he asserts, involves an essential principle of all practical enclosed arcs, and marked the beginning of the commercial enclosed arc lamp industry.

Consolidation of Manufacturing Companies.

The Siemens & Halske Electric Company, of Chicago, is reported to have consolidated with the Pennsylvania Iron Works, of Philadelphia, the combined capital to be $3,250,000. The consolidated companies will manufacture electric railway equipments, the electrical department to be at Chicago.

CANADIAN ELECTRICAL ASSOCIATION.

The seventh annual convention of the Canadian Association took place at Niagara Falls on the Canadian side, on the 3d and 4th of June, 1897, and was one of the most largely attended and interesting in the history of the association. The discussions were particularly full, every member, apparently, being pleased to give the benefit of his experience on every subject broached.

The officers elected for the ensuing year are as follows: President, Mr. John Yule (re-elected); vice-presidents, Messrs. C. B. Hunt and J. A. Kammerer; secretary-treasurer, Mr. C. H. Mortimer; executive committee, Messrs. J. J. Wright, F. C. Armstrong, John Carroll, O. Higman, A. B. Smith, A. A. Dion, F. A. Bowman, W. Phillips, W. H. Browne and William Thompson.

The address of President Yule was principally devoted to the subject of municipal ownership, which movement, it appears, is rapidly spreading in Canada. A strong appeal was made to the electric lighting interests to organize and secure legislation that will prevent the installation of municipal plants without the purchase of an existing private plant.

In a paper entitled "Why some Lighting Plants do not Pay," Mr. F. C. Armstrong said, that, speaking generally, it will be admitted there is no industry representing an equivalent money investment and possibility of public service which is so generally managed by men who know nothing about it as the electrical industry. As to the question of rates, he believes that in most flagrant cases of plants which positively refuse to show any margin on the right side, the remedy lies in cutting down the rates to a point which will force a large increase of business. He believes that the value of the arc-light contract to the average station is very doubtful. As to meter and flat rates, he considers that the latter may be the more rational, as a contract can be made whose terms are more representative than meter rate, of the real value of the service supplied. Mr. Armstrong does not believe in free wiring any more than in the principle that the wiring department should be conducted at a profit. The opinion expressed in the discussion was against flat rates. Mr. W. H. Browne, stated that his system was to divide the meter reading in lamp-hours per day by the number of lamps installed, and base the rate on the quotient; for the first hour, thus determined, the highest rate is charged and a decreased rate for each subsequent hour.

Mr. William Thompson, in a paper on "The Determination of the Heating Power and Steam Producing Value of Coals from a Preliminary Examination," gave methods for fixing the real value of coal on all the factors concerned, instead of basing such value simply upon the amount of carbon contained.

Mr. D. H. Keeley, in a paper on "Economy in Circuits," gave some examples of the calculation of circuits installed according to his system. The circuit advocated by Mr. Keeley has some similarity with the three-wire system. Two dynamos or sources of E. M. F. are required, but

instead, as in the Edison three-wire system, of connecting, for example, the positive brush of one machine to the negative brush of the other, the two positive brushes are connected together, and a line led from these, corresponding to the Edison neutral; between the two negative brushes a loop is led and lamps are connected between this loop which forms a closed circuit, and the line led from the brushes connected together. That is, considering a circular circuit, the outer conductor will proceed from the negative brush of one machine to the positive brush of the other, while the inner conductor will be closed and connected at one point to the two positive brushes.

Mr. C. E. A. Carr, in a paper on "The Commercial Aspect of Electric Railways," gave practical information on the construction and operation of electric railway systems of moderate size, the information being the result of the author's own experience and observation. One of the methods suggested for increasing traffic is to issue annually a handsomely illustrated booklet which contains cuts of all the interesting points along the line, telling briefly how to get there. Cars for trolley parties are also spoken of as a possible source of revenue.

Mr. John Murphy, in an article on water-driven plants, dealt principally with the matter of regulation, which he believes can be satisfactorily accomplished if the gates and all of their connections, from the water-wheel to the hand-wheel in the dynamo room, are so constructed as to move quickly, positively and easily. He considered that incandescent light and motors should not be run from the same wheel. He advised that a device be placed upon the shaft, such that a bell or gong will be rung at every change of speed, no matter how slight it might be, or in which direction. Another device recommended consists of a pair of friction pulleys mounted on a frame, and so arranged that if the speed exceeds a certain predetermined amount, a governor ball will move a lever, bring the friction wheels together, which in turn will operate to close down the gate. In the discussion, the consensus of opinion was that it is difficult to get close regulation with water-wheels, except under high heads.

In a paper on "The Steam End of an Electric Plant," Mr. A. N. Wickens thoroughly considers the subject of steam-engine economy. The owners of the smaller plants are advised to stop all small leaks and losses and get more heat out of the coal into the engine, and keep the engine in good condition. A thoroughly posted mechanical engineer should be engaged to look over the plant and advise where savings may be made.

Mr. J. A. Kammerer, in a paper on "Day Loads for Central Stations and how to Increase Them," dwelt upon the profit to be derived from carrying day loads, and advised station owners to endeavor to work up a motor service and increase his lighting service by giving inducements for burning daylight lamps in stores and elsewhere. He favored the use of polyphased machines and the running of motors, arc and incandescent lamps from the same circuit. In the discussion opinion was divided as to whether it is advisable to run lights and motors from the same circuit. Overlapping of the motor and light loads was considered a serious point.

"Accumulators—Their Application to Central Station, Station Lighting and Power," was the subject of a paper by Mr. W. A. Johnson, in which he showed how the economy of operation may be very largely increased by the installation of a storage battery, either for lighting or power stations. Practical directions are also given for the installation of such batteries.

In a paper entitled "How to Select an Electric Plant," Mr. George White Frazier detailed all of the various points to consider and what weight should be given to each. He shows that in a number of the machines, each in itself apparently well adapted to a desired purpose, there is one which may thus be determined to be the most economical under the given conditions, though its price may not be the lowest. In laying down the instructions that should decide the selection, electrical and mechanical efficiency come first, the other points being mechanical excellence and probable freedom from repairs, heat limit and regulation, and, finally, price.

CONVENTION OF THE INDEPENDENT TELEPHONE ASSOCIATION.

The movement toward the organization of the independent telephone interests which has been making rapid progress since the recent decision of the United States Supreme Court in the Berliner case, culminated at a meeting held at Detroit June 22d and 23d, which resulted in the formation of the Independent Telephone Association of the United States of America.

The attendance was very large, being estimated at not far from 500. As was natural at so large a meeting, the members of which were mostly unknown to each other, there was at the beginning considerable discordance in views, but towards the end of the meeting a policy was united upon which met with the acceptance of all except a few of the larger exchange owners.

The meeting was called to order by Hon. Charles Flower, Public Prosecutor of Detroit, and after some appropriate remarks, Mayor Maybory was introduced, who delivered an address of welcome. Judge Taylor, one of the counsel for the Government in the recent Berliner suit, in an address to the meeting reviewed the recent Berliner litigation, some of his references being couched in severe terms. He expressed the opinion that the Berliner patent is of no intrinsic value and would, if tried upon its merits, be pronounced invalid, as had already been done by Judge Carpenter. The decision of the Supreme Court, he said, has no bearing upon the validity of the patent as an invention, merely declining to cancel the Berliner patent on the ground of fraud. He added that this was the first case brought forward by the Government to set aside its own patent, and that it would very probably be the last one.

The decision implies that the fraud alleged must be proved by the same kind and amount of evidence necessary to set aside a horse trade, which is impossible, as the patent lawyers who direct matters of this kind are not such awkward fellows as to make an exposable blunder. Though the recent litigation has been a failure, Judge Taylor stated that it had an advantage in various ways. It has kept the Bell Company at bay for some time, giving independent companies time to organize and get on their feet; it has allowed the independent movement, supported by the people, to get fairly started, and has permitted the accumulation of important evidence that will be of the utmost value in future infringement proceedings.

The Berliner patent was pronounced "the most unblushing, barefaced, thinnest, unexceptionable, abominable fraud that has ever received the sanction of the Government." "It has not one single redeeming feature about it; it has not given the world one single idea about the telephone; it has not advanced the progress of the world one minute; there is not underlying the patent one single spark of merit; the telephone art was kept just exactly where it would have been if Mr. Berliner had never been born. No court has ever decided that it had any merit. The only court that has ever said a word about its intrinsic merit and its legal validity was the United States Circuit Court for the District of Massachusetts, and that has decided it was void. The Supreme Court of the United States has not undertaken to pronounce upon the validity of the patent, but went no further than to say that for the particular reason of alleged fraud in its issuance, the court saw no reason to interfere and would not; everything else was left out of consideration. That the patent application had been nursed in the Patent Office from year to year for nine years on purpose to extend its life was a thing which nobody who had ever looked into the record doubted for a moment, and neither the United States Supreme Court nor the Circuit Court of Appeals decided that it was not so."

JUDGE JAMES M. THOMAS.

President of Independent Telephone Association.

Judge Taylor spoke of the great benefit that would be derived through the association from the influence it might have on legislation and on the improvement of the patent law and system, and urged the members to proceed with their work of popularizing the telephone.

Judge Thomas, of Chillicothe, O., spoke of the objects of the association and made a plea for harmony in its deliberations. He referred in scathing terms to the contention that the telephone is a necessary and nat-

ural monopoly, and to the claim from the same source that the independent telephone movement had been a failure. To-day, he said, there are more than 1000 independent telephone companies doing successful business, and the independent movement has existed only during the past two years.

The American Bell Telephone was denounced by Judge Thomas in strong terms as a company whose rights have long since expired and is still endeavoring to hold a monopoly under its patents. The great progress of the independent telephone movement in a number of foreign countries was sketched, and the prediction made that unless the American Bell Telephone Company changes its present policy it will suffer in this country, as abroad, for at present there are hundreds of cities throughout the United States where the lessors of the Bell Telephone Company do not receive enough income to pay their employes. He stated that at present there are more than $20,000,000 invested in the independent telephone enterprise in this country, and added that a greater capital stock than all this money is the fact that the independent movement has the sympathy of the people, and that there exists in every locality where successfully managed independent telephones have been installed a local influence in favor of its success.

Judge Thomas, in conclusion said that if the American Bell Telephone Company keeps up its present policy they will find that the battle ensuing will be their Waterloo. "They will find that others have been building, while its officers have been scheming to make money; they will find, too, that our courts will uphold the law if brought under the state of facts proven; they will find, also, that it will not be trying the suit of the Government for the cancellation of a patent; they will find that evidence exists which, when the proper time comes, will be shown to the courts, and they will find that the courts will decide, as the judges presiding over them are bound to do, under oath, according to the law and facts. And while they boast of their victories and say nothing of the numerous defeats recently received; and while they boast of their great technical lawyers, of the many millions of money and the numerous expert witnesses that have been retained, still they will find that in this great country there are others equally learned who are ready and willing to espouse the cause of this movement, knowing that a great victory will reward their efforts. It will remain then for the American Bell Telephone Company to say what policy it will pursue, but it should understand that whether in peace or war we will meet them, and in peace greet them, in war surely defeat them."

The two main points that occupied the association during its meeting was the question of admission to membership of manufacturers of telephonic apparatus, and the amount of assessment on each of the members for carrying out the objects of the organization.

At first opinion appeared to be very strongly set against the admission of manufacturers, one of the grounds being given that they are breeders of dissension. The fact, however, that such manufacturers are largely interested in telephone exchanges and would therefore be represented in the association by proxy if not directly, led to the final defeat of the clause which disqualified them from membership; the article relating to representation being so amended that any corporation, partnership or individual engaged in the operation of an independent telephone exchange, toll line or system, may become a member of the association.

The discussion became very warm on the article of the constitution providing for the levying of assessments. As finally adopted it provided for a membership fee of $10, and the payment from time to time of such further assessments as the association, through its proper committee, may levy, not to exceed in one year 50 cents for each exchange or toll line company, and 50 cents per mile of toll line in use, carrying the wire or wires over which paid messages are transmitted.

The opposition to the above assessment was from the large exchanges, as the amount they would have to pay under it would approximate to a sum considerable enough, they thought, to enable them to defend alone any suits brought against them. Mr. W. L. Holmes, of the Detroit Telephone Company, the largest exchange represented, said that he was not prepared to enter any association that contemplated a law suit, and added "We do not fear any litigation with our own apparatus now in operation. We have been running two years and the Bell Company has not put forward the slightest intimation of any kind as to infringement."

During the discussion one of the members estimated that the number of independent telephones now in use is 150,000 to 175,000, and the extent of toll line, 2500 miles.

Under the constitution as finally adopted the object of the association is stated to be the protection of all independent telephone interests of common concern to the members of the association; the protection of subscribers to telephones and apparatus operated by members of the association; the bringing about of a reasonable charge for tolls and the rental of telephones, so that the telephone may be within the reach of the masses of the people; the bringing about of a complete system of intermunicipal communication and long-distance trunk lines.

A salary of $2500 per year is provided for the president, and a salary not to exceed $1000 per year for the secretary, both to have allowances for expenses; the treasurer is to receive a salary not to exceed $750 per annum. The executive committee shall consist of two members from each state, to be selected by the membership in the respective states, and an advisory board is provided for, which shall have full power to determine all questions, and transact all business of the association at all times when the executive committee or the association is not in session It shall direct the finances of the association and have full power to levy assessments whenever necessary, as provided in the constitution, and to appropriate money in the general fund to such use as in its judgment is essential to the welfare of the association. The officers elected were as follows: President, Judge James M. Thomas, of Chillicothe, O.; vice-presidents, H. C. Young, of Columbia, Pa., E. K. Hines, of Oskaloosa, Ia.; and Thomas Fricker, of Ashtabula, O.; secretary, W. J. Vesey, of Ft. Wayne, Ind.; assistant secretaries, G. W. Beers, of Ft. Wayne, Ind., and D. C. Dow, of New York; treasurer, L. A. Carr, of Durham, N. C.

THE MANUFACTURERS' TELEPHONE ASSOCIATION.

During the session of the National Independent Telephone Convention at Detroit a meeting was held of manufacturers of telephonic apparatus, and an association was formed having the name of "Manufacturers' Telephone Association." Mr. H. A. Taylor, of Madison, Wis., was elected president; William Rawson, of Ohio, vice-president, and J. H. Lee, of Baltimore, Md., secretary and treasurer. An advisory board was also appointed, consisting of T. C. Burns, of Chicago, H. A. Taylor, of Madison, Wis., and A. Batton, of Chicago. The meeting was held behind closed doors, and no disclosure made of the programme decided upon.

TRANSMITTING ELECTRICAL ENERGY WITHOUT WIRES.

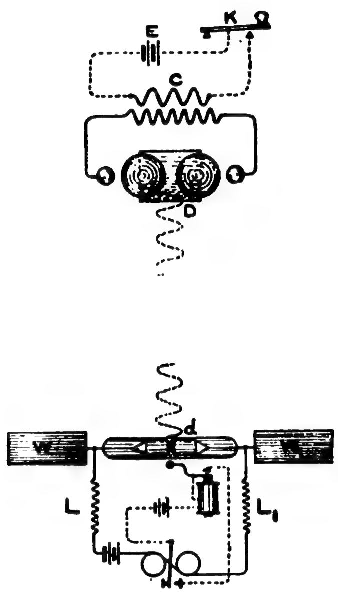
In a lecture delivered before the Royal Institution June 4, Mr. W. H. Preece explained the Marconi system of signaling through space by means of Hertzian waves, and from the report we gather the following details of the apparatus by means of which telegraphic messages have been sent over a distance of 9 miles without the use of wires.

The upper part of the accompanying figure represents the transmitter and the lower part the receiver. Two spheres of solid brass, 4 ins. in diameter, are fixed in an oil-tight case, *D*, of insulating material, so that a hemisphere of each is exposed, the other hemisphere being immersed in a bath of vaseline oil. The oil maintains the surfaces of the spheres electrically clean, avoiding the frequent polishing required by Hertz's exposed balls, and impresses on the waves excited by these spheres a uniform and constant form. The waves produced are about 120 centimeters long. The two spheres are placed between the sparking knobs of an induction coil of which *C* is the primary. When the key, *K*, is depressed, Hertzian waves proceed, as indicated by the sinusoidal curve, from *D* through space to the receiver.

The receiver consists of a small glass tube, *d*, 1½ ins. long, into which two silver pole-pieces are tightly fixed, being separated from each other by about a fiftieth of an inch; this thin space is filled up by a mixture of fine nickel and silver filings, mixed with a trace of mercury. The tube is exhausted to a vacuum of a sixth of an inch and sealed. The tube forms part of a circuit containing a sensitive telegraphic relay and a local cell.

Normally the metallic powder is an insulator, but when Hertzian waves strike it, the particles cohere, and the resistance is reduced to as low as 5 ohms; the local cell is then enabled to send current through the circuit to work the relay indicated in the lower part of the figure. The magnet in the

pended upon how far it could be got to dotted circuit actuates a trembling arm which taps the glass and causes the particles to continually disarrange themselves, as otherwise they would continue to cohere after the signaling waves have ceased and thus remain conducting. The relay may work a Morse recorder, thus printing the signals transmitted; in practice, the trembler is so connected as to operate only during the time signals are sent, and in doing so makes a sound whereby the message may be received by ear. "The exhausted tube has two wings, *W* and *W*, which, by their size, tune the receiver." (The report gives no



MARCONI TRANSMITTER AND RECEIVER.

further explanation of these important adjuncts,) *L* and *L* are choking coils which "prevent the energy from escaping."

A 6-in. induction coil has sufficed to send messages 4 miles, and in transmitting 9 miles a 20-in. coil was used. As Hertzian waves are propogated in the ether, they are not obstructed by hills. In experiments performed during Mr. Preece's lecture, the receiver responded when inside an iron box, also, when the transmitter was in the vaults of the Royal Institution building, the receiver being in the lecture room.

BURNED-OUT ARMATURE COILS.

BY GEO. F. WOOLSTON, JR.

Burned armature coils cause probably more delay in the operation of closed-coil arc dynamos than anything else. Wholesale burn-outs such as are caused by lightning are not referred to, but those where one or two coils go without any apparent reason. Usually the trouble starts in one coil, but if the machine is not stopped at the first sign of smoke, three or more coils must be rewound. Upon testing out for grounds, etc., everything shows up clear, and the attendant is sometimes at a loss to understand it.

The writer was at one time in charge of a number of these dynamos, which were required to be run day and night for long periods, allowing very little time for repairs and adjustments. Every now and then an epidemic of burn-outs would occur. Coils would go so fast that it was hard to keep them repaired. The whole trouble was finally traced to bad lamps on the line. Some of these lamps, when the carbon was almost consumed, would allow the arc to change so rapidly that the regulators on the dynamos could not work fast enough to keep the machine from "slopping over," or, in other words, an arc would form clear around the commutator. This was disastrous. It burned little jagged points in the segments, and caused some of them to short-circuit. If the short-circuit held (was not burned off) an armature coil gave out at once. It is needless to say that the lamps were at once overhauled and put in shape. When this was done, there were no more burn-outs.

It often happens that the dynamo regulator runs either too fast or too slow—regulators requiring motion from the dynamo being here referred to. In one case it shifts the brushes too far either way, and in the other it does not shift them quickly enough to compensate for changes in the line resistance A little experimenting will correct either evil.

In the case cited, the bad performance of some of the lamps was largely due to worn rods. The length of rod worn in a lamp depends upon the average length of carbon consumed per trim; at such times as the lamp is required to burn longer than usual, a part of the unworn rod enters the clutch, and the weight of carbon being less, it does not feed properly.

Direct-current motors are subject to the same trouble of coils burning out. Short-circuited commutator bars or cross connections cause much of this. The cross connections are necessarily crowded into a small space, and the constant rubbing is very likely to cause a short-circuit. Unless pains are taken to examine and repair these strips the coil will burn out again. Another frequent cause of trouble is the breaking of these cross-connecting strips. This is especially true with geared motors on account of the jar. The break will immediately show itself by a flashing at the commutator, the exact location being made known by a burnt spot between two segments, or two pairs of segments. A break of this kind can be temporarily repaired in some motors without removing the armature. A piece of insulated wire soldered onto the flange of the commutator on the outside, in such a way as to bridge the break, will allow the motor to be run until such time as permanent repairs can be made.

There seems to be considerable difference of opinion as to the use of sand-paper on commutators. In the writer's opinion it is impossible to lay down any rule for the care of commutators, for the reason that there are so many different kinds. Some are hard, some are soft and some are both hard and soft. The only way to keep one of the latter kind running at all is by the frequent use of sand-paper.

LONG-DISTANCE TRANSMISSION OF POWER.

During a recent discussion before an English professional meeting Prof. George Forbes stated that the distance to which electrical power could be profitably transmitted depended upon how far it could be got to compete profitably with other power; that might be as little as 100 miles where coal was cheap, or in certain circumstances as great as 1000 miles. The first time that real long-distance transmission came before him was through a letter from some person in Johannesburg, asking whether it would be worth considering the question of utilizing the Victoria Falls on the Zambesi for working the mines in Mashonaland and Matabeleland. His first thought was to consign so absurd a proposal to the waste-paper basket, but considing that a polite letter required a polite answer, he sat down to reply. He jotted down some rough figures to show the writer of the letter the absurdity of the idea, and as he wrote new economies occurred to him and cheaper means of transit presented themselves, and he came to the conclusion that the scheme was really most business-like. This result was made all the more certain after he had been to South Africa. From that time he had felt little fear about long distances for certain purposes, such as gold-mining, where in many cases other powers are costly, and especially as gold mines require power for the twenty-four hours. With regard to the question of dynamos and transformers, he said that no manufacturer who had not designed a plant for these large powers could have any idea of the economy when these large units are employed. He spoke more particularly with regard to transformers. In America it was proposed to charge them something like $15 per HP, but eventually they managed to get them for $2.50 per HP. They were informed by their critics that it was impossible to get anything like 96 per cent. efficiency with the low frequency adopted, whereas, as a matter of fact, they got as much as 98½ per cent. He thought the following statement of the results which were possible would be of interest not only to engineers, but also to those who contemplated using cheap water power and transmitting over long distances. The total investment per kilowatt to the different distances was as follows: To 100 miles, $100; to 200 miles, $220; to 300 miles, $400; to 400 miles, $650.

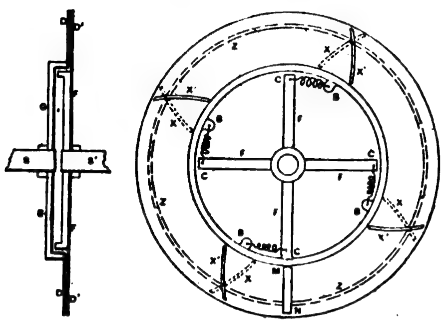
TRANSMISSION DYNAMOMETER.

The accompanying diagram illustrates the principles of a new form of transmission dynamometer which formed the subject of a paper read by Dr. Frederick Bedell before the American Society of Mechanical Engineers. *S* and *S'* are the two shafts between which the power is transmitted. *D* and *D'* are disks carried by the two shafts respectively, the former supported by the frame, *G*, and the latter by the spider *F*. In the particular form shown, the frame, *G*, carries four lugs, *B*, which are connected to the spider, *F*, by the springs, *B C*. The exact arrangement of the spring connection between the two shafts has, however, no direct bearing upon the principle of the dynamometer, which relates to the manner in which readings are made.

In the annular disks, *D* and *D'*, are curved slots, *X* and *X'*; one is superimposed upon the other with a point of intersection which, when the disks are in motion, and illuminated from behind *D*, will show a con-

tinuous ring of light, *Z*. As the torque varies and the springs, *B C*, become more or less strained, this ring of light will move outward or inward; the curvature of the slots is made such that the radius of the ring of light is directly proportional to the angle which one disk makes with the other.

In operation, there is placed in front of the disks a stationary opaque screen, *N*, and in the rear, opposite the screen, an incan descent lamp. The screen is calibrated in horse-power or foot-pounds, and the arc of



BEDELL DYNAMOMETER.

the circle of light appears across its face merely as a line, which line indicates on the scale the power being transmitted.

Such a dynamometer, being simple and direct-reading, should prove convenient not only in testing dynamos, turbines, engines, and revolving machinery of all sorts, but should find a useful place in power houses and factories. Thus the engineer in charge of a station, cable house or factory can at a glance see the exact amount of power which is being used, and he can regulate his turbines or the supply of steam to suit the demand.

NOTES.

Huge Orders.—The Westinghouse Company has recently received an order for fifteen generators of 5,000 HP each from the St. Lawrence Construction Company of New York, to be installed in its plant at Massena, northern New York. The same company has also received an order for five 5000 HP generators from the Cataract Construction Company, to be used in the extension of that company's plant now under way. These orders, aggregating 100,000 HP, are undoubtedly the largest ever received by any manufacturer of power machinery within the same time.

The Largest Trolley Party in the World.—During the convention of the Nobles of the Mystic Shrine held in Detroit June 7 to 10, what was probably the largest trolley party in the world was made up of the visitors. Sixty-seven open cars were used and 3,950 people took in the ride, the route being around the city and ending at the Water Works Park. The cars were gaily decorated with flags and the conductors and motormen each wore a boutoniere. Not a hitch marred the trip. The affair was managed by Messrs. A. A. Schantz, G. P. A. of the Detroit & Cleveland Steam Navigation Company.

Westinghouse Company's Annual Report. The annual report of the Westinghouse Electric & Manufacturing Company, shows assets on March 31, of $17,965,295, including $330,193 cash, $1,647,754 bills and accounts receivable, $1,636,612 material in stock, $569,966 advanced to leased companies, $5,964,898 stock and bonds, $455,115 real estate, $906,432 equity in new factory, $1,479,153 machinery and tools, $4,689,080 charters and franchises and $286,300 miscellaneous. The liabilities balance the assets by the addition of a surplus of $2,401,664. The report announces that during the year the Tesla polyphased motor patents were purchased for $216,000, $72,231 were paid for the entire capital stock of R. D. Nuttall & Company, and $58,000 for a controlling interest in the patents of the Electromagnetic Traction Company. The patent agreement with the General Electric Company is stated to fix the value of the patents of the two companies at 62½ per cent. of the total value for the General Electric and 37½ per cent. for the Westinghouse. The earnings for the year are stated to have exceeded the amount required for dividend on preferred stock. A regular quarterly dividend of 1¾ per cent. payable July 1, was declared on preferred stock.

Americans Abroad.—One of our English contemporaries laments that," the first big plum in the electric traction pie has been successfully extracted by our American friends "—the plum referred to being the contract for the equipment of the Central London Railway, which has been awarded to the English representatives of the General Electric Company, the amount involved being $1,375,000. Our contemporary adds that "It is extremely probable that before our big firms have put themselves in a position to compete successfully with the States in a business which has been growing there like a big snowball for the last ten years, some millions—not of dollars, but of sovereigns—will have been diverted from their legitimate destination, the pockets of the British workman and his employer." Mr. Frank J. Sprague has just returned from abroad with another English "plum," being an order for no less than forty-nine electric huge passenger elevators for use on the above underground line. These elevators will have a travel averaging seventy feet, and are to be used at the stations of the underground line to lower and raise passengers. The German representatives of the General Electric Company have secured the contract for the construction of the great electric traction system in Berlin, which has been under consideration for some years. The Stanley-Kelly Company has recently finished the installation of an extensive two-phased system in Montreal, Canada. Several other large foreign undertakings about to mature are likely to adopt American electrical machinery if public opinion abroad, rendered adverse by denunciations of our tariff legislation, does not intervene.

Technical Education.— Our esteemed contemporary, *American Machinist*, has for some months devoted considerable of its space to articles and letters on technical education, and many diverse views on the subject have been presented. The opinions offered are, as a rule, extremely dogmatic, and bring to mind the definition once given of orthodoxy and heterodoxy : " Orthodoxy is my doxy—heterodoxy is the other fellow's doxy." The professor and mathematics have naturally come in for some hard blows, not, however, without raising the suspicion that "sour grapes" had something to do with the condemnation. From a recent issue we select the following opinion for quotation as it resumes in a remarkably clear and concise manner what we believe to be the modern tendency of technical education; the writer, we will add, introduces himself as "an old, or at least middle-aged, practical engineer, and an 'ancien élève de l'Ecole de Mines de St Etienne' " :

"In my opinion the true function of the technical school is to teach well and thoroughly the sciences upon which the different branches of engineering rest, with the application of said sciences to said branches—and no more. That is to say, it should teach the science but not the art of engineering. The first it can, the second it cannot do. The practice of engineering can only be learned in real, and not play work, and under the direction of practical instructors (of which personal experience is one of the best). If the college professor is thoroughly competent, from long study and practice in teaching, to instruct in the science, he cannot possibly be competent to instruct in the art, because life is shorter than the combined lengths of both art and science. If he has some practical knowledge, so much the better; only he should not attempt to impart it as such, but simply use it to modify and direct his theoretical instruction."

The Bliss School of Electricity.—On the 29th and the 30th of May the Bliss School of Electricity, Washington, D. C., held an exhibition of work done by the students, no less than three large rooms being occupied by the exhibits. In the draughting room were numerous mechanical and free-hand drawings. The dynamo laboratory was devoted to apparatus constructed by the students. The best work shown consisted of an ammeter, two induction coils, slidemeter bridge, microphone, motor, tangent galvanometer, and motor for a wattmeter. Besides testing and other school apparatus, there were in the instrument laboratory a working model of a power station, an electric railway and a two-phase induction motor. The railway is controlled by a switch on the power station switch-board. The car is a very complete model of those on the Metropolitan line. When it nearly reaches either end of the track, it automatically reversed and goes in the other direction. The interior and ends of exterior are lighted by miniature incandescents. The induction motor was of considerable interest to the electrically inclined. It consists of a Gramme ring, within which is a rotating armature, originally intended for one of the fan motors. Two-phase current was supplied by a motor generator. The exhibition was enlivened by the use of the school's gramophone. Rev. Dr. Green, vice-president of the Columbian University, addressed the graduating class, which numbered twenty-four. Addresses were also delivered by Rev. E. W. Bliss, President L. D. Bliss and Mr. E. T. Friman. A gold medal was awarded to Mr. E. B. Hazard and a scholarship to Mr. Edward J. Friman.

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Thermo-Electric Batteries.

The article under the above head on page 266, should bear the signature of C. T. Reed.

Loss in Stoppage of Cars.

What importance small things may assume in the aggregate is illustrated in the article by Prof. Hering on another page on "Loss in Stoppages of Electric Cars." From the data of actual tests it is shown that the cost of one stop on each trip of a car during a year may amount to at least $70 annually for a 15-car road, or $467 for a 100-car road, not counting wear and tear. It is also shown that by careful handling of the controller, on a very moderate estimate a saving of $1067 per year may be made by a 15-car road, and no less than $7000 per year on a 100-car road. No manager, of course, need be told that a saving will result from fewer stops and skillful handling of cars, but few probably have any idea of the dollars and cents involved. If the European practice of stopping only at definite places could be adopted, the saving would be a very large item. While this may be impossible in American cities, motormen at least can be so instructed in their duties as to result in reducing the loss in stopping to a minimum. The saving, indeed, may be sufficiently large to justify the institution of a regular course of training in charge of a skillful man, with prizes for motormen who profit most by the lessons received.

Safe Wiring Rules.

When at the Niagara Convention Captain Brophy in his concluding remarks on the work of the N. E. L. A. Committee on Safe Wiring, announced that the various insurance and electrical interests through their delegates had finally arrived at an agreement on a single code of safe wiring rules, the news was greeted with a burst of applause. Doubtless most of those present had remembrances of the days when, under a multiplicity of rules, one insurance inspector frequently condemned the work passed by another; and though during the last several years the situation in this respect has been very much improved, there has been no positive assurance of its permanency. We venture to say that when the movement was first started having for its object the formulation of a code of inspection rules that would meet with the approval of both the electrical and insurance interests, few thought that it could meet with success, and many believed that the outcome would be an aggressive warfare over antagonistic codes in which the electrical interest would be the main sufferer. That the deliberations and negotiations extending over a period of more than a year culminated so fortunately, is extremely creditable to the diplomatic ability of the leaders in the movement, and of these the greatest meed of credit is due to Mr. W. T. Hammer. Mr. Hammer for years independently labored to attain the end now reached, often under discouraging circumstances, and it was he who organized the recent conference of expert representative of the various interests affected by insurance rules, and was the greatest force in bringing about final harmony of views.

The American Institute of Electrical Engineers.

The secretary's statement of the financial condition of the American Institute of Electrical Engineers at the end of the last fiscal year shows a balance of $818.51, as against a balance of $239.99 at the end of the previous fiscal year. The statement also shows that the Institute possesses a permanent fund of $956.48, the principal of which was contributed some years ago during a movement to raise money for building purposes. According to the point of view, the financial condition of the Institute may be considered satisfactory or unsatisfactory. It meets running expenses, as conducted during the past year, which will satisfy some. On the other hand, great economy is necessary to attain this end, with, in addition, the use in the past of life membership fees for current expenses. The year ended, it is true, shows a net balance of $818.51, which may perhaps be reduced somewhat when all past obligations are discharged. This favorable showing, however, has been obtained by a curtailment of expenditures for meetings and *Transactions* during the past year, to the amount of about $900; otherwise the balance on hand would have been less than that brought over from the preceding year.

If we mistake not, all of the more prominent sister professional societies provide for a fund, the main object of which is to procure permanent quarters. The Society of Mechanical Engineers owns the building in which its headquarters are located, and has also a growing fund to meet the demand that will arise in the future for more extensive quarters. The Society of Civil Engineers has possessed its own building for some years, and at present is completing a new one of considerable architectural pretensions. Although the Institute of Electrical Engineers has now been in existence almost thirteen years, the only provision for a building fund are a few hundred dollars contributed for that purpose some years ago, to which no significant additions have since been made.

It, therefore, is a matter worthy of attention whether some provision should be made to place the Institute in line with its sister societies, instead of continuing from year to year without any provision for the future—in fact, by expending life-membership fees, actually drawing upon the future. Indeed, a greater income for current expenses would be desirable, for at present there are no funds for such purposes as binding exchange periodicals. Of these

there is now a great accumulation, representing almost the entire electrical periodical press of the world, and which in bound form, would make the Institute library a valuable source for reference. The establishment of a library is really a matter of primary importance, since it would serve to attract additional members, give prestige to the Institute and be an adjunct not easily duplicated by any rival organization that in the future may be formed. Increasing the fees of full members appears to be the only solution that offers itself, and by so doing the Institute would merely be following the precedent set out by other societies when a similar necessity presented itself.

The Telephone Convention.

The recent telephone convention at Detroit, an account of the proceedings of which appears in other columns, had a most significant interest, both as marking the strength of feeling generally existing against the American Bell Company on account of the Berliner patent, and from its organization of the independent telephone interests with a view to protection against the danger foreshadowed by the recent Supreme Court decision in the Berliner case. The convention was conducted with marked ability, for while the extreme animus undoubtedly held toward the American Bell by the delegates in attendance would at times find expression, the leaders were careful that the new organization should not commit itself openly to an aggressive policy. At the same time, due warning was given that if attacked, the independent telephone interests had not only the will, but were also provided with the means, for a defence which, supported by popular favor, might easily assume a most aggressive form. The tone of the meeting was vigorous in the extreme, and as the representation included delegates from a number of state associations recently organized and including large numbers of exchanges, it can speak even at the beginning of its career in a voice that cannot safely be unheeded.

As to the probable action which will follow the organization of the association, this must be left to surmise, as the skillful leaders at the meeting gave forth no intimation. On the face, the association is organized to resist attacks upon the interests of its members and not to stir up litigation or play an aggressive part. On the other hand, the feeling of injustice at the present situation with respect to the Berliner patent, not only on the part of members, but also of the general public, will probably soon lead to some important development, though this may await aggressive action on the part of the American Bell Company. At any rate, we have now for the first time since 1891—the date of the Berliner transmitter patent—a prospect of the validity of that patent being made an issue which will be vigorously contested to the bitter end, with the aid of competent legal ability and untrammeled by the conditions which made the recent Government suit the veriest farce. As representing the largest constituency of electrical readers in the world, the AMERICAN ELECTRICIAN tenders its wishes for the success of the new organization and for the triumph of its cause.

The Niagara Convention.

The Niagara Convention passes into history as the most brilliant of a long line of successful electric light conventions. Much of the success was undoubtedly due to President Nicholls—indirectly through the interest reawakened in the purposes of the association by his active administration, and directly from the high character of the programme prepared for the Niagara meeting. With Mr. Samuel Insull succeeding to the presidential chair, there is every assurance that the association will be maintained in its present high state of efficiency, and that the next convention will be no less successful than the recent one. As Mr. Insull is also president of the Edison Association of Illuminating Companies, his election is par icularly significant, as it marks a *rapprochement* of two bodies that formerly, if not actually antagonistic, yet viewed each other with suspicion and were not on speaking terms.

Of the papers read, two, or perhaps three, would have been much more appropriate if presented before the American Institute of Electrical Engineers, their character being entirely too technical for a mee ing industrial and commercial in its aims and membership. The merely perfunctory paper, so familiar in the earlier days of the association, was not marked by its absence, one at least, and possibly two, of the papers read falling under this head. The paper by Lieut. Patten, though somewhat technical in its character, had the advantage that it announced a very ingenious method of frequency transformation which, it is hoped, will soon be tested on a practical scale. Mr. White in his paper on the Niagara-Buffalo line gave a large amount of engineering and commercial data on high-voltage line construction that will be of much service to the electrical engineering profession. The papers by Prof. Thomson and Mr. Arthur Wright were the star contributions, as much from their appropriateness to the occasion as from the intrinsic and timely importance of their contents.

Undoubtedly the most important subject now before central station men is the question of the proper method of charging for current. Lieut. Cahoon in his paper, while adhering to the present system which ignores—or, at least, only very partially recognizes—the relative value of different classes of customers, offered a method whereby the flat meter rate may be fixed according to a rational method and not by mere guess-work, as is usually the case. Mr. Arthur Wright, in his paper, set forth the details of the Wright maximum-demand system, which promises soon to be in force in every English station, and which, in a slightly different form, has been applied in several of the larger American stations with great success.

According to this system, the consumer is charged, first, for the use of that portion of the plant fixed by the maximum demand he makes upon the plant, and, second, for the actual cost, in fuel, labor and other operating expenses, of the current he consumes, plus a percentage sufficient to allow for depreciation and dividends. That is, the consumer pays the fixed charges on the portion of the plant kept ready for his service, which portion corresponds, not to his average, but to his maximum, demand; and the cost, with a profit added, of producing the current used.

To illustrate, suppose the total investment in a plant corresponds to a fixed charge of 14 cents per day, and that the cost of current, together with a profit on the same, is 4 cents per KW-hour. Then if a consumer at any time during the month draws upon the station at a rate that will require a kilowatt of the station's capacity to be at his disposal, he will be subject to the charge of 14 cents per day. If, now, he uses daily 1 KW-hour, his monthly bill will be charged at the rate of 18 cents per KW-hour. If he uses 2 KW-hours daily, the rate will be half of 22 cents, or 11 cents; for 3 KW-hours it will be a third of 26 cents, or 8⅔ cents; for 4 KW-hours, 7½ cents; for 10 KW-hours daily, 5.4 cents, and for 24 KW-hours daily, 4.2 cents. It will thus be seen that each consumer is charged in proportion to the value of the service rendered, the long-hour consumer getting benefit from using his share of the station and distributing copper to the best advantage, and all consumers paying their share of the charges on the part of the plant at their service during the time they do not use it, as well as during the time that they do. The system is so rational in all its details, it deals such even justice to every consumer, and, above all, so cheapens illumination to long-hour customers as to place gas out of competition, that it deserves the most careful study from every American central station manager.

DESIGNS FOR SMALL MOTORS.—III.

ONE-FOURTH HP MOTOR WITH DRUM ARMATURE.

BY CECIL P. POOLE.

Of the accompanying drawings Fig. 1 represents the field magnet and a journal yoke. The magnet is of the familiar single-coil type employed by Westinghouse, Jenney and others. The core is of round Norway iron, 2 ins. in diameter and 9 ins. long over all. The ends are turned tapering as indicated by dotted lines, to insure intimate contact with the yokes; the taper is from the full diameter to 1 3/4 ins., and begins 2 ins. from each end. The pole-pieces are of cast-iron. Fig. 2 gives a plan view and Fig. 3 a face view of one pole-piece, from which all the essential dimensions may be obtained. The arms which support the journal yokes are cast solid with the pole-pieces, and their horizontal thickness tapers from 1/2 in. at the pole-piece to 1/4 in. where the yoke is bolted on.

In fitting the magnet frame together the best procedure is to bore the tapered holes in the lower part of each pole-piece and turn the ends of the magnet core to the same taper but just a trifle *large*; then dress each taper down very gradually with a fine file (the core being run in a lathe) until the pole-piece can be pushed on by hand far enough to bring the end of the core within 1/32 in. of the back surface of the cast iron. The pole-pieces and ends of the core should be punch-marked, so as to insure finally mounting each pole-piece on the end to which it was fitted. After dressing down the ends of the core as above described, drill and tap in each end a hole for a 1/4-in. machine screw, the purpose of which will be apparent by glancing at the right-hand end of the magnet in Fig. 1, where *C* is a four-armed claw or spider with a hole through the center where the arms intersect. The arms are 3/16 in. thick, measured at right angles to the bolt and taper from 3/16 in. to 3/8 in. thick measured parallel with it. One of these spiders is used at each end, though the drawing shows it at only one end of the machine.

After drawing one pole-piece home solid by means of its spider and bolt, slip the other pole-piece on loosely and clamp the pole-pieces lightly between two iron plates with planed surfaces, applied between the journal arms, so as to keep the four horns of the pole-pieces in alignment; then force the second pole-piece home by means of its bolt and spider, and clamp the horns hard between the iron plates. The bottom surfaces of the cast-iron pieces should then be trued up on a planer or shaper and the clamps taken off the pole-piece horns.

The next operation is boring the armature chamber and the seats for the journal yokes. The armature chamber bore is 4 3/16 ins; the seats for the journal yokes, marked "finished part" in Fig. 3, are bored or cut to 4 5/8 ins. diameter, and this must be done before the position of the machine is disturbed after boring the armature chamber. This completes the machine work on the magnet, except the bolt holes.

The journal yoke may be made of brass or any composition metal. The bar is 3/16 in. thick and 1 in. wide, except near the ends, where it flares to correspond with the width of the arms. At each end is a right-angled lug, 1/2 in. thick after machining; these lugs fit the seats in the ends of the iron arms, and the yokes should be fitted to the magnet immediately after finishing the machine work on the latter, and before it is taken apart to put on the coil. The box portion is 1 1/2 ins. long over all, 3/16 in. of its length being on the inside of the yoke, and 1 1/8 ins. on the outside. As shown by the plan view of the yoke in Fig. 1, there are stiffening webs starting flush near the ends of the yoke and attaining a width of 3/4 in. at the box; these are 1/8 in. thick. The box is 7/8 in. in outer diameter and bored to 11/16 in. inside; it is bushed to 3/8 in. diameter. These latter dimensions, excepting the final inside diameter of the bushing, may be varied to suit individual ideas, as may also the design of the box. The only essential measurements are those of the yoke-bar, the length of the box and the bore of the journal bushing. The journal yokes are held in place by 1/4 in. cap-screws passing through the iron arms and tapping into the lugs of the yokes.

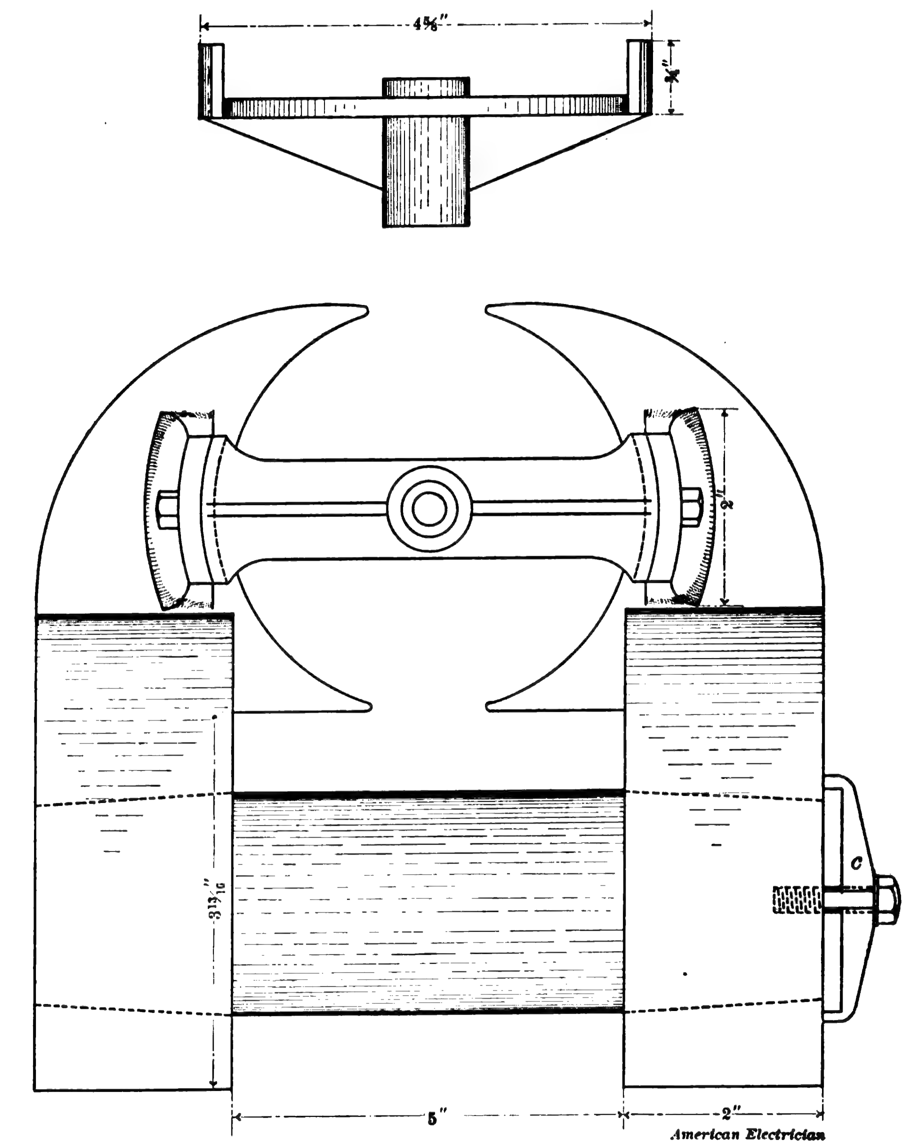


FIG. 1.—FIELD MAGNET AND JOURNAL YOKE.

Figs. 4, 5 and 6 show the shaft and armature core, the latter in cross-section, an armature disk, and the shell and head. The disks are of charcoal iron, 4 ins. outside diameter with a 1 1/4-in. hole in the center and a 1/8-in. key-seat, annealed after punching and key-seating; there are eighteen slots 3/8 in. wide and 3/8 in. deep. The shell and one head are cast in one piece (of brass) and consist of a barrel 1 1/4 ins. outside diameter (when finished) and 2 ins. long, with a head, *s*, at one end, 3 1/8 ins. in diameter and tapered in thickness from 1/4 in. near the center to 1/16 in. at the periphery; at the opposite end of the barrel is a cross-bar, 1/8 in. thick, cast with the barrel, and of the shape shown, being 3/8 in. wide where it joins the barrel and 3/4 in. at the center. A 1/2-in. hole is drilled in the center of this cross-bar and another in the center of the head, *s*, at the other end of the barrel; the shell is mounted on a mandrel, the barrel turned down to fit the hole in the armature disks, and both sides of the head faced off smooth. A 1/8-in. key-seat 3/16-in. deep is cut in the barrel so as to come in the center of one end of the cross-bar, as shown; a 1/8-in. × 1/4-in. feather, or parallel key is laid in the key-seat and the disks threaded on the barrel and compressed against the head by the collar, *h*, and two bolts (not shown) passing through the collar and inside the barrel, and tapping into the head at the other end. This collar, *h*, is of brass, 3 1/8-ins. in diameter and tapering

from 3/16 to 1/16-in. in thickness when finished. The opening in the center should fit the outline of the cross-bar on the end of the barrel at least closely enough to prevent the collar from shifting under stress of centrifugal force; the collar must be finished up smooth on both sides. A disk of insulation should be put on next to the brass head before the iron disks are put on, and another insulating disk should go between the last iron disk and the clamping collar, *h*.

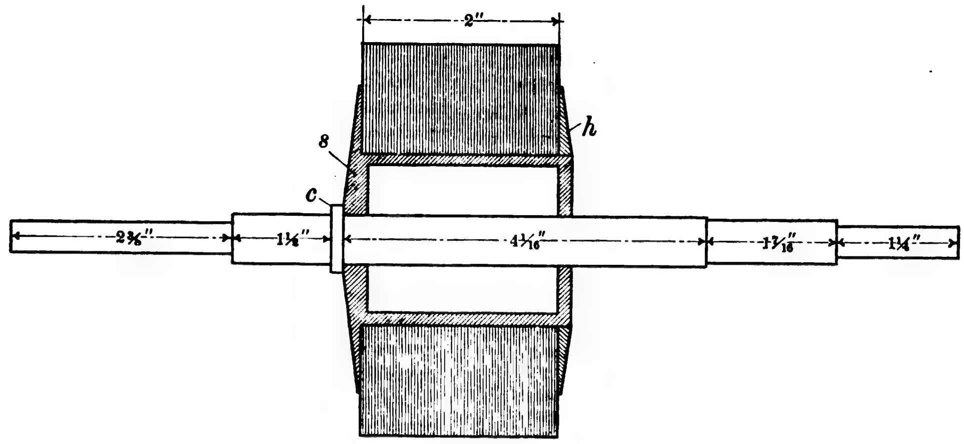


FIG. 4.—SHAFT AND ARMATURE CORE.

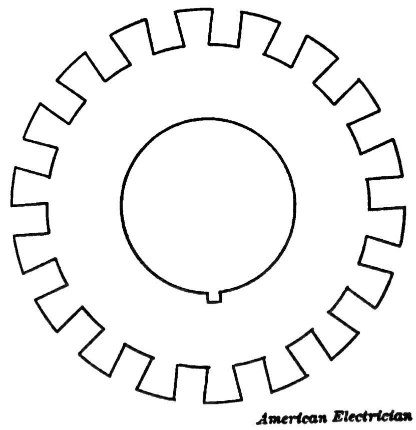
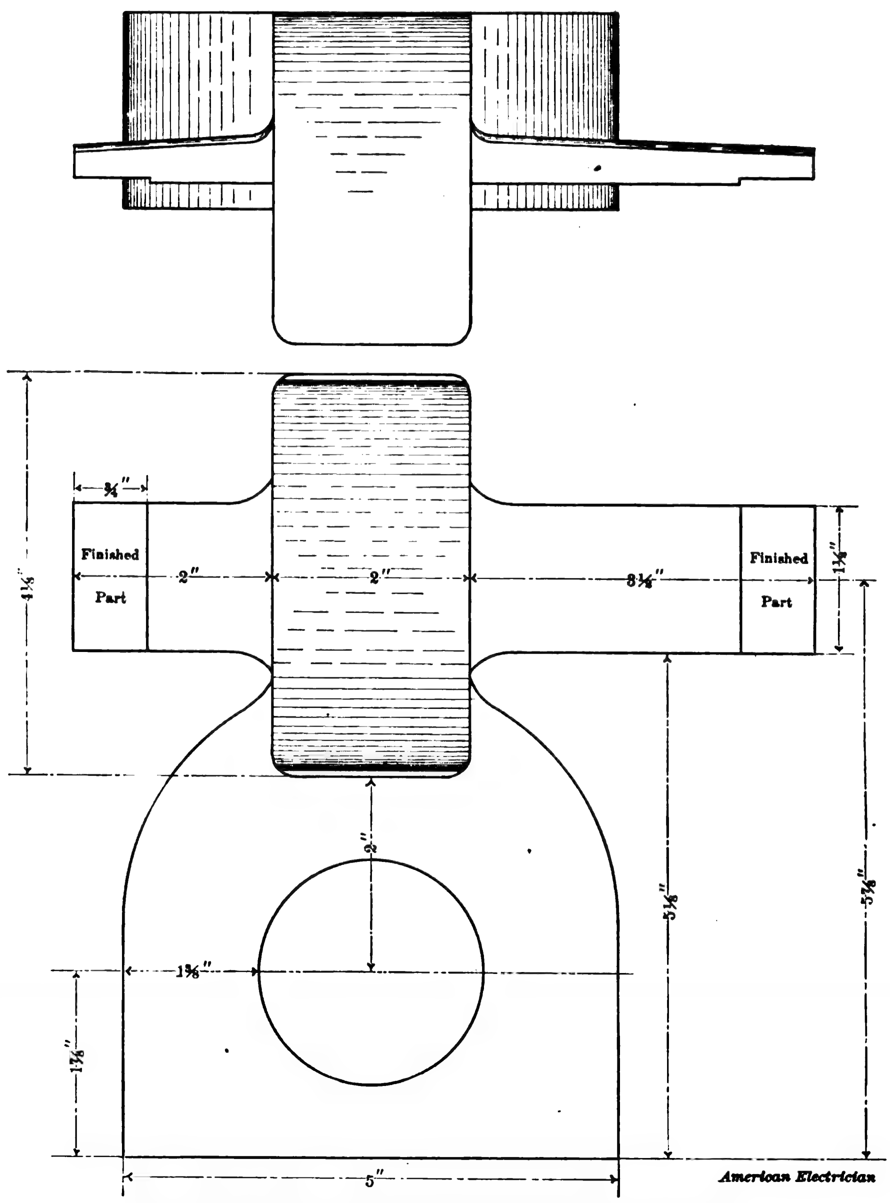


FIG. 5.—ARMATURE DISK.

If the slots are cut in the core with a milling machine, the disks must all come off the barrel to have the burrs removed and also be reannealed; the key-seat will insure their returning in the original angular position. It is much better to have disks with the slots punched before the first annealing. The shaft is 10¾ ins. long over all; ½ in. in diameter in the largest part, 7/16 in. where the commutator goes, and ⅜ in. in the journals. A 1/16-in. × ⅛-in. collar, *c*, is shown back of the armature, the purpose of which is merely to "locate" the armature shell; it is not absolutely necessary, however, and may be left off if desired. The easiest way to provide for it is to make the shaft of ⅝-in. stock, leaving the original metal to form the collar when turning the shaft to proper diameter. The armature shell may be keyed to the shaft or pinned obliquely through the thick part of the head; it must be positively secured by some such means.

The commutator shell must be bored to fit the 7/16-in. portion of the shaft, and must not exceed 1¼ ins. along the shaft. The lugs where the wires are attached to the segments may project toward the armature ⅛ in. or so. There must be eighteen segments, and a diameter of 2 ins. is recommended. The quadrant carrying the brush-holders should be fitted to the inner end of the journal box, and carbon brushes not smaller than ¼ in. × ½ in. (one on each side) on the contact surface should be used. If the machine be used as a dynamo (it will maintain five or six 110-volt lamps) metal brushes of the same surface should be used to reduce the resistance of the brush contact.

The field coil contains thirty-seven layers of No. 28 double-cotton-covered wire. After the magnet is fitted as described in the beginning of the article, it is taken apart and two circular magnet heads of fibre, ⅛ in. thick and 3¾ in. outer diameter, are put on with a driving fit, care being taken that the distance along the core from outside to outside of the heads corresponds with the distance between the pole-pieces when the whole is assembled. A groove must be cut on the inner face of one head from the center to the outer edge, in order to lead out the starting end of the field wire, and this must be covered with two layers of oil paper to prevent short-circuiting the successive layers of the coil. The core must be insulated with three layers of shellaced muslin between the heads, and the field wire put on evenly, care being taken not to "spread" the heads; if the winding is carefully done the coil will be 216 turns in length. The number of turns in length is not a vital matter, but the depth *must* be thirty-seven layers. The ampere-turns are the same no matter what the length of the coil, but it should be as long as practicable to reduce the heat loss.



FIGS. 2 AND 3.—PLAN AND FACE VIEW OF ONE POLE-PIECE.

After winding the coil and securing the ends, one pole-piece is put on solid and the other one slipped on until it begins to bind, when the journal yokes must be inserted between their arms, and the bolts put in as far as possible without jamming. Then by tightening up the journal-yoke bolts and the pole-piece bolt together, being particular never to draw the yoke bolt hard against the arm, the frame will come together in its original position. As an additional precaution it may be set on a true plane surface, and if the base of the loose pole-piece gets out of alignment, tap the horn lightly until the frame is true on the bottom. The magnet frame must be provided with a non-magnetic base; hard wood is as good as anything, the frame being secured by flat-head brass machine screws from below, two in each casting, countersunk in the wood.

The armature winding is divided into eighteen coils, each having forty-five turns of No. 22 double-cotton-covered wire, nine turns wide and five turns deep in the slot. The slots must be insulated with troughs of muslin and mica or, preferably, flexible micanite, 0.03 in. thick. The troughs are easily made by cutting the material into strips, 2¼ ins. long by 1⅛ ins. wide, and slitting the ends so as to permit the projecting portion of the trough to be folded back flat against the core. Before putting in the troughs, a disk of heavy drilling, 3¼ ins. in diameter, should be secured to each end of the core by means of varnish, and the outer faces varnished and allowed to nearly dry.

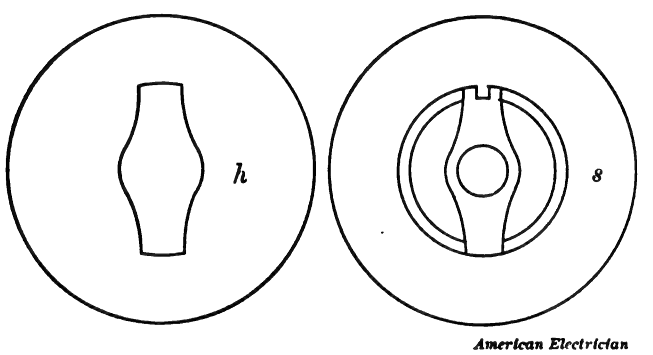


FIG. 6.—SHELL AND HEAD.

Then put in the troughs and put on two more muslin disks, varnishing the whole, and bake until thoroughly dry. Instead ot winding each coil in diametrically opposite slots, take slots lacking one of being precisely opposite.

A good plan is to make a sketch of an armature disk and number the slots from left to right successively around the periphery. Then wind the coils as follows, the coil numbers indicating the order in which the coils are put on. not the order in which they are connected to the commutator.

Coil number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Starting in slot number.	1	10	13	4	7	16	2	11	15	6	14	5	18	9	3	12	8	17
Ending in slot number.	9	18	3	12	15	6	10	1	5	14	4	13	8	17	11	2	16	17

Each pair of coils must be covered with muslin where they cross the heads before the next pair is put on, and before coil No. 8 is wound on top of coil No. 1 in slot No. 1, the bottom coil must be insulated by a strip of micanite laid in the slot; this is true of every bottom coil.

After the winding is on, and before connecting up to the commutator the band wires should be put on. Use No. 19 B. W. G. soft tinned-iron wire, known by hardware dealers as "white stove-pipe wire," for the bands, and put them on under as heavy pressure as possible without endangering the armature shaft. Two bands of eight turns each, ½ in. from each end of the core, will suffice. A strip of mica, between two strips of fuller-board, must go under each band, and the bands should be soldered at intervals, *not* all the way around. Four tin clips located equidistantly, with a dab of solder at each, will give ample security.

The technical data for this machine are as follows:

TERMINAL E. M. F., 110 VOLTS.	
Armature current, normal	1.9 amps.
" " maximum	2.3 "
" resistance, warm	3.33 ohms
Field current at 110 volts	.25 amp.
" resistance, warm	440 ohms
C^2R loss in field	27½ watts
C^2R " " armature	12+ "
Hysteresis loss in "	20− "
Magnetic flux per square inch:	
In field core	90,000 lines
In pole-pieces	39,000 "
In air-gap	25,250 "
In armature teeth	68,000 "
In " core	56,000 "
Co-efficient of leakage	1.4
Electrical efficiency	84 per cent.
Commercial efficiency (friction 10 p. c. estimated)	65 "
Revolutions per minute	2000

If it is desired to build a smooth-core machine, the armature core must be made 3⅝ ins. in diameter and two grooves ⅛ in. wide and 5/16 in. deep must be cut in the face of the core at opposite points for the reception of driving teeth. These are two pieces of fibre, ⅛ in. thick, ½ in. wide and 2 ins. long, set on edge in the grooves, and projecting 3/16 in. above the surface of the core. The core must be thoroughly covered with two layers of micanite cloth. The number of coils is the same as before, but the coils will be 18 turns wide and 5 deep, and in this case they are not superposed, the depth of a coil (5 layers) being the total depth of the winding. The guiding diagram, therefore, must divide the perphiery of the armature into 36 spaces instead of 18, because each space now contains one side of only one coil. The smoothest winding will be as follows:

Coil number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Start in Space number.	1	19	7	25	31	13	3	21	27	9	33	15	23	5	11	29	35	17
End in Space number.	18	36	24	6	12	30	20	2	8	26	14	32	4	22	28	10	16	34

Care must be taken in connecting up either of the armature windings to take the *starting* ends of the coils in proper succession to the commutator segments; the outer end of each coil goes to the segment on the *right* of the one to which the starting end is led. The smooth-core armature is banded just as the slotted one is, except that German silver wire must be used instead of tinned iron.

AMERICAN TELEPHONE PRACTICE.

ISOLATED TELEPHONE LINES.

BY KEMPSTER B. MILLER.

So far, only the underlying principles of telephony, and the construction of those parts which go to make up the complete telephone instrument, have been considered. Before taking up the question of telephone exchange systems, it will be well to consider, briefly, the various forms of service on single or isolated lines—that is, on lines which are not connected with an exchange. The telephone exchange is merely an aggregation of many lines, and its complexity is apparently lessened when we consider it as being made up of a great number of similar circuits, each of a simple character.

The simplest form of service is where but two instruments are used—one at each end of a line. Such a line is called a private line, for as there are but two instruments connected, privacy of conversation between them is insured. Private lines, and in fact all lines, may be divided into two general classes—grounded and metallic-circuit. The simplest form is the grounded-circuit line, shown in Fig. 1. Here the line wire, *l*, terminates at each end in one of the binding posts of each instrument, while the other binding post of each instrument is connected with the ground at *G*. The simplest way of regarding the grounded-circuit line is to consider the earth as the return conductor; that is, to consider that a current generated in one instrument flows through the line wire to the ground connection at the remote end of the line, and back through the earth to the ground connection at the starting point.

The metallic-circuit line differs from the grounded-circuit line, in that a separate wire is used instead of the earth for the return conductor. As is shown in Fig. 2, it consists of two separate line wires connected respectively to the two binding posts of the instruments at each end.

In contradistinction to the private line, is the party line, where several instruments are connected in a single circuit. There are two general methods of connecting instruments on party lines. First, the series, and second, the bridged or multiple method. Each of these may be applied to either grounded or metallic-circuit lines.

In Fig. 4 is shown a series grounded line. In this it will be noticed that a circuit can be traced from ground to the left hand binding post of instrument 1, through that instrument and out at the right-hand binding post to line, thence to the left-hand binding post of the next instrument, and so on to ground at the other end of the line.

Fig. 3 shows a metallic-circuit line with the instruments arranged in series. The only difference between this and the grounded-circuit series line is, that a separate wire is used for the return side of the circuit, in place of the ground. In this figure, the two intermediate instruments 2 and 3 are looped one in one side of the line and the other in the other. This is not absolutely necessary, as all the instruments might be placed in one side of the line, using the other side simply as a return, but it is desirable, from the fact that it keeps

the line balanced; that is, it keeps the resistance and other electrical properties of the two sides of the circuit equal. It is therefore well, in arranging a series metallic-circuit line, to place half of the instruments in one wire of the circuit, and the other half in the other. The reasons for, and the advantages of this, will be taken up fully when the electrical properties of the line are considered.

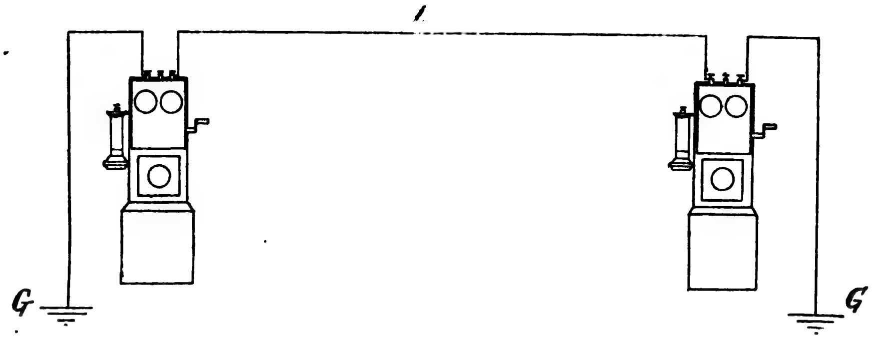


FIG. 1.—GROUNDED-CIRCUIT LINE.

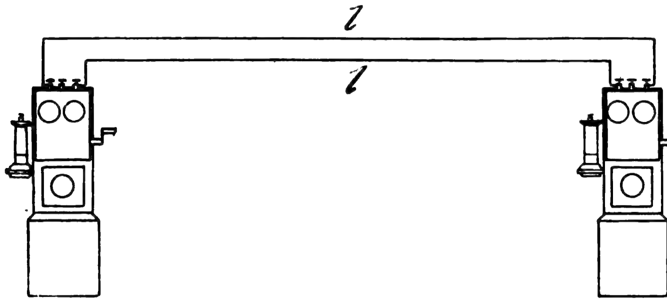


FIG. 2.—METALLIC-CIRCUIT LINE.

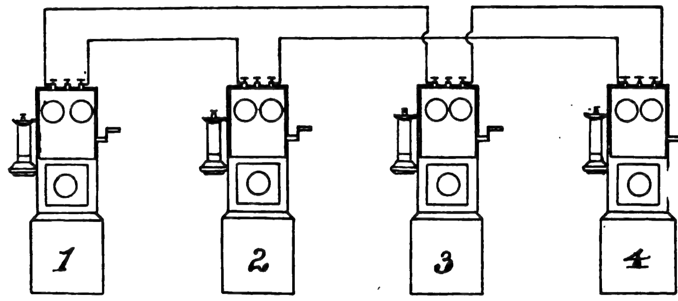


FIG. 3.—METALLIC-CIRCUIT SERIES LINE.

The bridging or multiple system is now rapidly superseding the series arrangement in all party line work. Two types of bridged lines are shown in Figs. 5 and 6, Fig. 5 being a bridged grounded line, and Fig. 6 a bridged metallic line. In Fig. 5 it will be seen that the line wire, *l*, runs continuously through all of the stations, and that each instrument is connected in a separate bridge wire, *b*, between this line wire and ground. In Fig. 6, both of the line wires run continuously through all the stations, and each instrument is in a separate bridge wire, connecting these two line wires. In this class of party line arrangement, the call bells are invariably wound to a high resistance; usually 1000 or 1200 ohms, and are usually left permanently in circuit. Each instrument, therefore, forms a separate "leak" or path for some of the current to find its way back to the source. When the generator of any instrument is operated, the current passes out over the line, and enough of it finds passage through the coils of the ringer magnets of each instrument on the line, to actuate its bell, and thus all of the bells are rung at once. Owing to the high retarding effect of the ringer magnets, the voice currents, with their much higher rate of vibration, are not allowed to pass. When conversation is being carried on between any two of the instruments, only an almost inappreciable amount of the voice current finds its way through the various ringer coils. These currents are not materially weakened, as would be the case if low-wound ringer magnets were permanently bridged across the line.

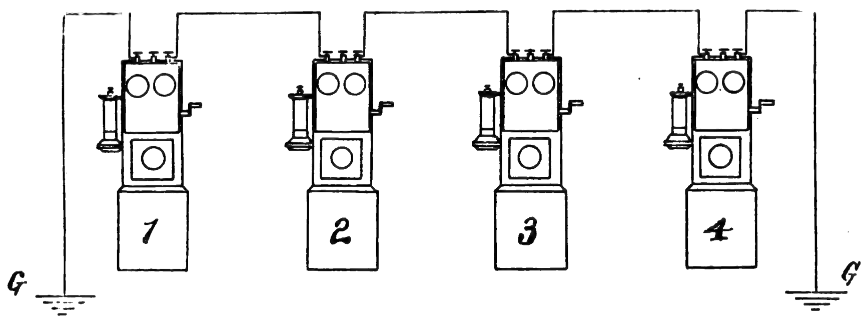


FIG. 4.—SERIES GROUNDED LINE.

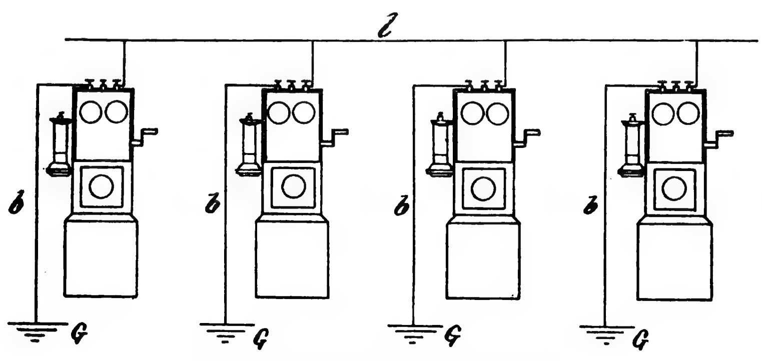


FIG. 5.—BRIDGED GROUNDED LINE.

In the series party line, it is, of course, necessary to arrange the circuits so that the call-bell magnets will be normally directly in the circuit of the line. This is necessary, in order that every instrument shall, when not in use, be in proper condition to receive a call from any other instrument. When two parties are engaging in conversation, the call bell magnets at their stations are cut out of the line, by virtue of their receivers being removed from the switch hooks. The ringer magnets of the other instruments on the line, however, are still in the circuit, and it follows that voice currents generated at either of the two instruments in use, must pass, serially, through all of the ringer magnets of those instruments not in use. This, of necessity, has a considerable weakening effect upon the strength of the transmission, and is the chief objection to the series line. In order to minimize this effect, the call-bell magnets are wound to a low resistance, usually from 60 to 100 ohms. The injurious effects of the resistance and retardation of the generator armatures, are nicely avoided by the use of the automatic shunt around the generator armature, described in a previous article.

The ringer magnets on bridged lines are, as has been said, wound to a high resistance, and are usually left permanently in circuit. So little of the voice current finds passage through the various paths afforded from one side of the circuit to the other by these permanently-bridged call bells, that an almost unlimited number of instruments may be used on a single line with good talking results. The practical limit is only reached when the generator will no longer furnish enough current to ring all the bells.

In the early days of telephony, grounded wires were almost universally used. While they are used satisfactorily in telegraphy, it is, in many cases, impossible to obtain good service with their use in telephony. Grounded circuits are open to several serious objections which can be totally avoided only by the use of metallic-circuit lines. In long grounded lines, earth currents due to the difference in potential of the earth at the two ends of the line, will often produce

such noises in the instruments, as to render their use impossible. Changes in the strength of the magnetic field of the earth, will also often produce sharp fluctuations of current in the line wire, and at times render it unavailable for use. The chief difficulty with the grounded line, however, is due to induction from neighboring wires.

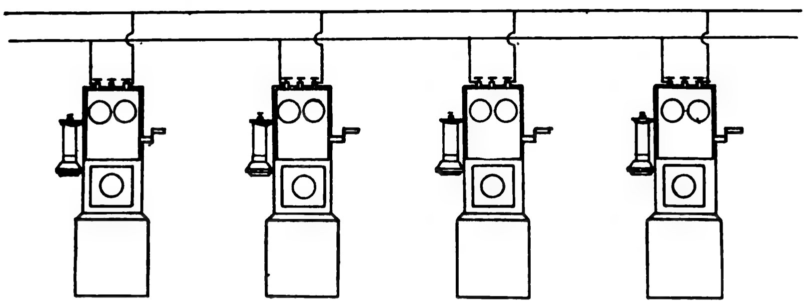


FIG. 6.—BRIDGED METALLIC LINE.

Where two grounded telephone lines run parallel for a considerable distance, conversation on one of them is easily heard on the other, due to induction between the two lines. This is commonly known as "cross talk." The currents in a telegraph wire will, in the same manner, produce sharp clicking in the instruments on a neighboring telephone line. Electric light and power wires, even though located on the opposite side of a street from the telephone line, will cause an intolerable buzzing in the telephone instruments. With a properly constructed metallic circuit, all of these objections may be entirely removed. For this reason, all of the telephone lines in large cities should be metallic circuit. All successful long-distance lines, as, for instance, those between Chicago and New York, are metallic circuits entirely free from ground. Of course, the cost of construction of metallic lines, is greatly in excess of that of a grounded circuit; but the advantages arising from this construction are great enough to warrant the additional expense. In a subsequent article, the electrical and mechanical properties of the line wires will be considered at greater length, it having been the purpose of this article to place before the reader a brief summary of the various kinds of lines in common use.

INTERIOR WIRING.

CONCEALED WORK.

Most interior wiring is concealed, but this section refers to a class of concealed work that is installed after the building is complete. It is a matter in which great care must be exercised, for not only must the cutting and boring be carefully done, but where wires are run through places that cannot be inspected, such as in the walls or between the floor and ceiling, it is very necessary to be sure that they are sufficiently insulated.

Such cases as this arise more frequently in dwelling houses, for it is there that the owner will be found most particular. The wireman is given the location of the lights and has to lay out his installation under the stipulation that all work shall be concealed, and if he is conscientious he further limits himself by the additional condition that the job shall be a safe one.

The first thing to do is to select a path from cellar to garret for the risers. In some cases it will be found best to begin at the upper story and feed down, and in others to begin from the cellar and feed up. In any case there must be two or more wires from cellar to garret from which the various floor circuits may be tapped.

As a usual thing the best place will be found next the chimney. Very often there is a continuous chute there. Moreover, closets are almost sure to be adjacent on every floor in which distributing cabinets can be placed without objection. Ventilating passages often make excellent raceways, and the writer knows of cases where a chute ordinarily used as a drop for soiled linen from the chambers to the laundry in the basement was utilized. In short, if the wireman uses his judgment and ingenuity, he is almost certain to find a way.

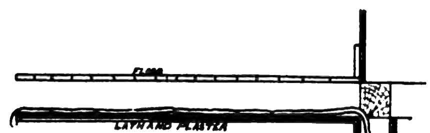


FIG. 1.—METHOD OF COMING THROUGH RAFTER.

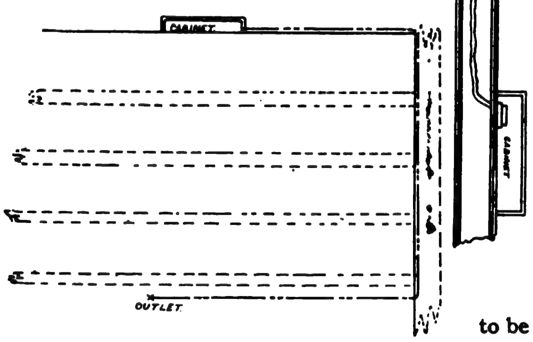


FIG. 2.—AVOIDING RAFTERS BY RUNNING ALONG MOP BOARD.

Having decided where the risers shall be, they must be installed in a protected position. Merely pulling the heavy insulated wire into the raceway is not sufficient; it must be protected by tubing of some sort. Brass or iron-armored conduit or flexible tubing will answer. If the risers are near a chimney, a tubing insulated with something other than an asphaltic compound is preferable, as such an insulator is liable to be reduced to a semi-liquid condition by a slight rise in temperature. Of course, it is obvious that the further the wire and its conduit are placed from the source of heat, the better. Unless the conditions are favorable as to room, it is easily possible that a stiff conduit of the metal-armored class cannot be manipulated, and flexible tubing will have to be used. The latter may be conveniently drawn into the chute with cords, weighted and let down from above. Taps from the protected wire should be made in accordance with the principles laid down in the previous article, and much information on this point can be obtained from the catalogues of the makers of the conduits that are used.

The wire should be stranded for greater ease in drawing into the conduit, and powdered soapstone blown into the tubing will greatly facilitate the drawing in of the wire.

Having established a distributing center on a floor, wires may be led down to supply fixtures on the ceiling below and upward to deliver current to the ceiling lights of the floor on which the cabinet is installed. In this way the number of cabinets can be minimised. Side lights on any floor can be fed from above or below, as is most convenient. It is to be distinctly remembered in such an installation as this that the material is but a small part of the cost, and it should always be liberally used if labor can be saved in greater proportion, as is usually the case.

In running the wires through ceilings and walls, the ordinary principles of bell wiring are brought into play except that instead of fishing a wire through, a flexible tubing is used which is not quite as easy to install. In wiring a ceiling it is always better, if possible, to take up some of the flooring above, and it may be necessary to do so for the reason that the partition rafter will have

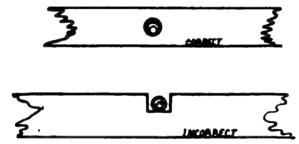


FIG. 3.—METHODS OF PASSING THROUGH BEAMS.

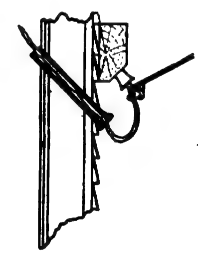


FIG. 4.—DRIP LOOP.

to be bored diagonally, as shown in Fig. 1. in order to come down the wall to the cabinet. If it is a case of passing up the wall it will be convenient to remove the mop board temporarily.

It will be readily understood that a conduit can only be drawn in parallel to the rafters, and that this direction may be at right angles to the direction that it is desired to go. In such a case it is almost always possible to remove the mop boarding and run around as shown in Fig. 2.

In vertical partitions and walls it is always better to drop the cords from above and fish for them with a hooked wire. It sometimes happens that cross studding interferes with this and another method of approach has to be chosen. Beams and studding can always be located by tapping with a hammer and noting the sound. The distribution of the wiring in the topmost rooms

in a building should always be accomplished from the loft overhead and similarly the wiring of the first-story fixtures should be done from the basement below.

Cutting and boring unless carefully done is liable to do great damage. Many a handsome piece of stucco work or decorated ceiling has been ruined by carelessly boring from the rear. Mortising beams and rafters, as shown in Fig. 3, may seriously weaken them and place the responsibility of any accident on the careless wireman. At the end of the beam near the support a mortise either on the under or upper side weakens the beam no more than any other method, but if the cut is to be made in the middle of the beam between the supports such a mortise may easily reduce the strength of the beam 30 per cent. The outer fibres are those that carry the most of the stress, and to cut them is to cut at the vital parts. If the beam must be cut it will be weakened less by a hole in the center, for at the center of the beam there is minimum stress. It is always easier to mortise, and to save work many ignorant men have seriously weakened buildings. Center holes are also always safer when penetrating upright studding.

The entrance holes into a building should always be bored diagonally upward to prevent the entrance of water, and a drip loop should be provided as shown in Fig. 4.

In executing work of this kind where so much is concealed, the insurance inspector should be notified when the work is begun and its nature should be outlined to him. Otherwise the contractor may be obliged at its own expense to tear up floors to expose for inspection work that the insurance inspector may suspect. It is a good idea to have the work inspected before the wire is drawn into the tubing, for by blowing through the tubes it can be demonstrated that a continuous tube exists from outlet to outlet. In all work in which the device of fishing through walls or ceilings has been used this should invariably be the case. It is well to cultivate a reputation for safe work, for subsequent installations will be inspected with much less friction between inspector and contractor.

PRACTICAL DETERMINATION OF MEAN PRESSURE.—HEATING WITH EXHAUST STEAM.

Paradoxical as it may appear, no writers indulge so largely in theory as do those who wish to be known as "practical writers," and writers on steam engineering of this class are most numerous. It is doubtless for this reason that the average steam engineer holds the word "theory" in such disdain, for he is more largely the victim of theorizing than is a man in any other occupation. We use here the word "theory" in its popular but not correct sense—that is, in the sense of hypothesis, speculation and mere personal vagary. There seems to be an irresistible tendency on the part of the average writer on practical subjects to branch off at every opportunity into what he considers scientific writing, though by education and opportunity he be absolutely unfitted to appreciate the meaning or limitations of theory.

Some months ago we showed in these columns how utterly absurd are the methods given by most writers on the indicator card for obtaining, by construction on an actual card, the point of cut-off or the amount of clearance. Both of these methods, it was shown, rest upon the hypothesis that the expansion and compression lines of an indicator card are parts of a hyperbolic curve. This is not only not true in theory, but, of course, is absurd, from the point of practice. Owing to condensation, wiredrawing, leakage, etc., under no circumstance can the expansion or compression line of an indicator card follow any curve based upon adiabatic expansion, and even if it could, the hyperbolic curve does not represent the adiabatic expansion of steam, but of a hypothetical gas that does not exist in nature.

The writers to which we refer usually also give a rule for calculating the mean pressure in a cylinder upon the basis of the maximum pressure and the number of expansions. The formula given for this purpose is (1 + hyperbolic logarithm of number of expansions) divided by the number of expansions. It is, of course, evident that since the above

EFFECTIVE MEAN PRESSURES IN CYLINDER OF NON-CONDENSING, SLIDE-VALVE ENGINES.

Cut-off in fraction of stroke.	Effective mean pressure in per cent. of maximum pressure.
1-10th	15
1-8th	20
1-6th	28
1-5th	32
1-4th	40
1-3rd	52
3-8ths	54
1-2nd	67
5-8ths	78
2-3rds	81
3-4ths	89

expression refers to an indicator card the corners which are right angles and the steam expansion line, a portion of a hyperbolic curve the case does not approach that practice. To show how wide the variations may be, we give above a table by D. K. Clark, showing the relation between the mean effective pressure and pressure of admission for different points of cut-out, the data being based upon calculations of actual indicator cards taken from slide-valve, non-condensing engines, and is therefore entirely practical.

If by means of the hyperbolic formula the mean pressure of a non-condensing engine were calculated for a cut-off of one-tenth and a pressure of admission of 100 lbs., it would be found to be 23 lbs.; whereas, from the table we find the actual card of a non-condensing slide-valve engine would give a mean effective pressure of 15 lbs. If the same calculations were made for a cut-off of one-half and the same pressure of admission, the hyperbolic formula would give a mean effective pressure of 82 lbs., while the table shows that actually it would only be 67 lbs.

The data in the table given should not be accepted as of general application, for it is quite evident that the amount of condensation, type of valve, etc., will give a difference of mean pressure for the same cut-off in different cylinders of the same dimensions. For example, as the condensation depends upon the quality of the steam and the efficiency of its working, it may vary from nothing to 60 per cent., while the amount of compression will also influence the result. It would be an interesting exercise for the engineer to calculate on a series of cards the ratio, in per cent., of the mean pressure and the pressure of admission for different points of cut-off. By this means he may check from time to time the economy of operation, as variations in percentage will of course, indicate changes in the steam or in the working efficiency of the engine.

One of the mooted points among engineers is the economy of exhaust heat. There is an excellent reason why there should be a difference of opinion on this subject, because, while it may in one case be economical to utilize exhaust steam for heating, in another case it may be decidedly uneconomical. This follows from the fact that if a back pressure is put on an engine in order to distribute exhaust steam through a heating system, the amount of work the engine has to do to overcome this back pressure is a constant.

Whether none of the exhaust steam is used in the heating system or all of it, it is quite evident that beyond a point when the amount of exhaust heat utilized is equal to the additional heat supplied by the engine in order to overcome the back pressure introduced, it will be economical to utilize the exhaust; while if a less amount of exhaust heat is utilized it would be preferable to use live steam instead of placing a back pressure load on the engine.

To illustrate by a numerical example, suppose we have a 25-HP non-condensing engine using 40 lbs. of water per horse power per hour; also assume that in order to properly circulate the steam throughout a heating system it will be necessary to place a valve in the exhaust pipe of the engine which will produce a back pressure of 3 lbs. per square inch; we will further suppose that the engine cuts off at one-half stroke, and that the pressure at admission is 100 lbs.

Referring to the table, we find that the mean pressure corresponding to one-half stroke is 67 lbs., which will be reduced by the back pressure to approximately 64 lbs. for the reason that the part of an indicator card thus cut off would approach a rectangle. The horse power of the engine is thus reduced in the ratio of 3 to 67 or, say, 4 per cent. Should the work this engine has to perform require its horse power to be kept up to 25, the point of cut-off will have to be increased, and we will suppose that in so doing the economy of working would not be materially changed.

As the horse power is 25, 4 per cent. of this is 1 HP, or 40 lbs. additional steam would have to be supplied the engine to keep it working at its original rate. The allowance of steam for heating is usually 300 cu. ft. of space per pound of steam per hour, so that the 40 lbs. would correspond to a space to be heated of 12,000 cu. ft. Therefore if the space to be heated is less than this, it would be more economical to use live steam, while if the space is greater, the economy increases, being, of course, a maximum when all of the exhaust steam is used for heating purposes. It has been assumed that the amount of heat in exhaust steam is equal to that in live steam, which assump-

tion does not introduce any significant error.

A still simpler method of determining the point at which the economy from exhaust heat begins, is to find the horse power for the given engine which corresponds to the amount of back pressure it is necessary to put in the exhaust; multiplying this by the number of pounds of water used per horse power per hour and by 300, will give the minimum cubic contents of the space that may be economically heated.

LOSS IN STOPPAGES OF ELECTRIC CARS.

BY PROF. HERMANN S. HERRING.

In answer to the query made in the last issue under this heading by "S. Mountain," concerning data of the relation between the amount of energy required to propel an electric car and the number of stops made dura trip, I would say that from a large number of tests I found that the difference between making a stop and start at a station and running past it varies from 75 watt-hours to 100 watt-hours according to the grade and load, the average for ordinary conditions with a partially loaded, 7½-ton car being 85 watt-hours per stop. These tests were made by running the car over a road on which definite stopping places were designated, and a different number of stops made on successive trips, each trip being repeated for the same conditions until the readings agreed. The car was loaded with sand bags and weighed on car scales. A Thomson portable recording wattmeter and a Boyer speed recorder were placed on the car, and records were kept of the watt-hours, time, stops and load for each half trip. The difference between the watt-hours required for a different number of stops enabled the watt-hours per stop to be determined.

These values being obtained from about 100 such tests are fair average results, but cannot be depended upon for any particular case, as conditions may cause a very large variation. But as an illustration of how these small values aggregate, the following figures may be interesting: Assuming the cost of electrical energy at 1 cent per kilowatt-hour, one stop would cost .085 cent, nearly one-tenth of a cent. At this rate, the cost of making one extra or unnecessary stop on each trip for fifteen trips daily would amount to 1.28 cents per car per day, and $4.67 per car per year; for fifteen cars, $70 per year, and for 100 cars, $467 per year, merely for one extra stop per trip. This does not include the cost of brake-shoes and wear and tear, nor the capital invested in the increased size of the power house.

Taking an actual instance of engine-house located where two lines of cars pass the door, thirty cars making fifteen round trips a day and each car passing the engine-house twice on each round trip, it was found that on this same basis it costs the railway company for electrical energy alone, seventy-six cents per day or $278 per year to stop its cars at this one place. Even should the assumption of one cent per kilowatt-hour prove too high, yet the results are important.

The inquirer asks "If an electric car, in traveling 5 miles (at an average speed of 10 miles per hour) makes sixty stops, and absorbs a definite amount of energy, expressed in kilowatt-hours, how much less energy will be required to propel the same car, under the same conditions, the same distance, but only making thirty stops?" In answer to this I would say that for city running with the ordinary 7½-ton car, moderately loaded, 1.4 would be about the average number of kilowatt-hours required per car mile, when eight is the average number of stops per car mile, and 10 miles per hour the average speed, judging from a large number of tests. On this basis it would require 8.7 kilowatt-hours to run this electric car 5 miles at 10 miles per hour and make sixty stops. Thirty stops less, at .085 kilowatt-hours per stop is 2.55 kilowatt-hours, which subtracted from 8.7 leaves 6.15 kilowatt-hours required to make the trip with only thirty stops, a difference of 29 per cent. These calculations are only approximate, but are based upon good average figures.

About 74 per cent. of the total energy required for propulsion is expended for accelerating and lifting the car, and 26 per cent. for horizontal traction, which shows the importance of utilizing as much as possible of the energy stored in the car in starting and in going up grade. Various methods have been suggested of either storing the surplus energy in accumulators or else throwing it back into the line. There is no system in commercial form at present, but there doubtless will be soon, as the importance of the subject warrants serious attention. If a saving could be effected of one-half of the energy stored in an ordinary electric car under average city conditions, in being lifted and accelerated it would amount to 763,000 ft.-lbs. per car mile, or an equivalent of 287 watt-hours. On the basis of one cent per kilowatt-hour this would be .287 cents per car mile and for a 10-mile trip would be 2.87 cents; for fifteen trips, 43.1 cents per car per day, or $157 per car per year. For a fifteen-car road this would amount to $2355 per year and for a 100-car road, $15,700, which at a capitalization of 5 per cent. would be equivalent to $47,100 and $314,000 respectively. Obviously, the saving in power-house machinery would also be very great.

In reference to the effect of careful handling of the controller, I would say that the difference between the kilowatt-hours per car-mile required by two motormen, is very marked. A number of experiments were made in order to obtain some data. A good average motorman was selected and instructed to run his car in the usual manner. The other motorman was instructed to run the car in the most careful manner, allowing it to "drift" as much as possible and to use the brakes as little as possible. The same car was used in both instances, and was run on regular schedule time, making the same number of stops. The careful motorman used only 80 per cent. of the kilowatt-hours used by the "regular," although the latter was not careless, but rather above the average motorman. The difference of 20 per cent. in the kilowatt-hours used by these two motormen represents average conditions and not exceptional ones, but for the sake of avoiding possible exaggeration and allowing that such expert motormen cannot be readily obtained, it would be perfectly safe to halve this figure and take 10 per cent. as the amount of energy that can readily be saved by more careful handling of the controller, while on most roads the larger value, or at least 15 per cent. could be saved without doubt.

A few calculations based on a saving of 10 per cent. may be of interest, being the gain that would result by using less power on the line. Taking the average performance in city running on a 10-mile, fifteen-car, fifteen-trip road as 1300 watt-hours per car-mile, a 10 per cent. saving amounts ot 1.3 cents per trip, 19.5 cents per car per day, $71.20 per car per year, and $1067 per year for the entire road, or for a company operating 100 cars this amounts to over $7000 per year. These figures may appear startling at first, but they are based upon data obtained from a large number of tests, and under the conditions of actual service, and are by no means extreme or unusual values; they can be taken as very fair values, and err in being too small rather than too large. They show the importance of properly training the motormen and inspectors, as the ordinary motormen of to-day undoubtedly use more energy than is necessary.

The difference between two ordinary motormen making the same trip under similar conditions is from 3 to 8 per cent. Motormen can very frequently be seen keeping the current on until just about to stop and then jamming down the brakes to stop the car in its length, thus utterly wasting the kinetic energy. When running down grade they keep the current on much longer than necessary to give the car the necessary start, and often throw the controller on before releasing the brakes and put the brakes on before shutting off the current. These cases, though small in themselves, amount to formidable quantities in the aggregate, because they occur almost continually. It is very important, however, to make use of the momentum and allow the car to "drift" as much as possible. In this way the greatest saving can be effected. The following calculations may be of interest in showing the magnitude of the energy possessed by a moving car:

An ordinary single-truck street car weighing, with passengers, 17,200 lbs. (8.6 tons), and having a traction coefficient of 12 lbs. per ton, would require a horizontal draw-bar pull of 103 lbs. on the level. At a speed of 10 miles per hour the kinetic energy would be 57,500 ft.-lbs., which would enable the car to drift 560 ft. theoretically, and probably 300 ft. actually. In city work, especially, a mere acceleration up to a speed that will carry the car by drifting to the next stop is usually all that is necessary. The experiments made show that the schedule can be adhered to within 1 or 2 per cent. with such careful running.

The following calculation shows the energy stored in a car in going up a grade: Using the car mentioned above and going up a 3 per cent. grade for 500 ft., the potential energy stored in the car would be 258,000 ft.-lbs. In going down the same grade, the force exerted on the car, which is the com-

ponent of the weight along the grade, would be 516 lbs. Subtracting the friction, that is, the draw-bar pull on the level, 103 lbs., leaves 413 lbs. not required, which either produces acceleration or is wasted in the brakes. The energy required to propel the car down this grade is the friction, 103 lbs. times 500 ft., or 51,500 ft.-lbs., which subtracted from 258,000, the potential energy at the top of the grade, leaves 206.500, which is a surplus and is stored as kinetic energy in the car in reaching the foot of the grade, if no brakes are used. The velocity of the car at the foot of the grade would be 27.8 miles per hour, and with a friction of 103 lbs. the car would go about 2000 ft. on a level after reaching the bottom of the grade, due to its own momentum, assuming the friction to be constant. Actually, this would be much less, due to the wind resistance and the increased friction at higher speeds, etc., but even at 50 per cent., that is, 1000 ft., the distance would be three times the length of the up-grade, or 1500 ft. from the top of the grade to a point where the car would stop. This shows the great amount of energy stored in the car in going up-grade, which is mostly wasted by the brakes in slowing up and stopping on down-grades. Although it is impossible in many cases to run under these ideal conditions, it is nevertheless important to bear this question in mind, and avoid the use of brakes as much as possible.

In brief, therefore, the following should be every motorman's maxim: *Use the brakes as little as possible and drift as much as possible.* Care in this direction will result in a large saving of energy at the station, and care in starting cars will also result in a saving that is well worth considering.

Further data concerning this subject can be found in an article entitled "Electric Car Tests," which appeared in the *Electric Railway Gazette*, Aug. 31 to Nov. 23, 1895. Reprints of the latter will be gladly sent by the author to any one especially interested in data concerning the operation of electric cars.

FAULTS AND HOW TO FIND THEM.

Fortunately for those who desire to estimate and correct the errors in ammeters, there is a current-measuring instrument that can be placed in series with the instrument to be tested which is so nearly a standard that the results will be satisfactory. This is the Thomson standard balance instrument. In this instrument the retarding force is gravity and the repulsion between two coils is weighed. The coils contain no iron, and once the constant of the instrument is determined, it remains the same for all time provided the instrument is not abused.

The constant of such an instrument is determined by passing a certain current through an electro depositing bath and the instrument in series. The reading of the instrument is noted and also the time in seconds that the current is on. The negative electrodes are carefully cleaned and weighed before the experiment begins and at its close they are weighed again and the increase in weight noted. From this weight and the time that the current has been flowing, the latter can be absolutely calculated, and knowing the true value of the current, the constant of the standard balance can be obtained.

The use of the electro-plating bath as a check on the value of a current is essentially a laboratory experiment. The negative electrode has to be prepared with great care, both before and after depositing, and the weighing scales have to be very delicate. Moreover, unless the solution is prepared to certain specifications and its temperature be

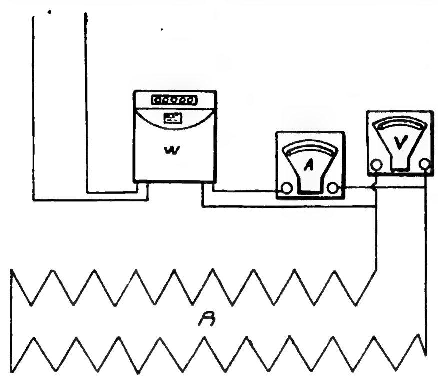


FIG. 1.—CONNECTIONS FOR CALIBRATING WATTMETER.

a certain quantity, errors are sure to result. The only excuse for such a complicated and tedious method is its extreme accuracy.

The solution must be a half saturated solution of copper sulphate to which one per cent. of strong sulphuric acid has been added. The gain in weight per ampere of current per second is .0003287 grammes at 12 degs. C., with a gain plate of less than 50 sq. cm. When the gain plate exceeds 50 sq. cm., the constant becomes .0003284, and if the temperature increases to 23 degs. C., these constants should be reduced by .0000001 grammes. The gain plates should be immediately removed from the solution after the current has been cut off and washed in clean water. A convenient device for drying is to flood the plates with alcohol and after draining set fire to it. The method is so

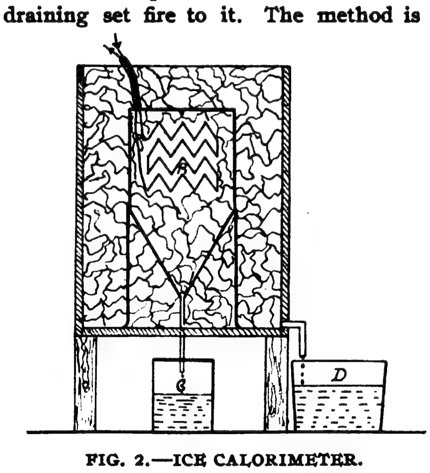


FIG. 2.—ICE CALORIMETER.

accurate that the slightest carelessness, such as touching the depositing surface with the finger or allowing the least dust or moisture to collect thereon will affect the result.

The electrolytic method involves so much work that it is customary to use three baths in series, partly to preclude errors on account of failure to handle one of the plates properly, and partly to serve as a check and increase the accuracy by providing the mean of three measurements.

The calibration of the recording wattmeter is a more commercial problem, for by this instrument electric energy is sold and therefore its accuracy interests both the user and the seller of current.

A paragraph on the discussion of units will be of assistance in understanding the calibration of such an instrument. The unit of electrical work is the joule, and a circuit which consumes one joule per second is said to be using one watt, the latter unit being a *rate of work*. If the circuit uses one watt for one hour, it is said to have consumed one watt-hour. Thus for every one of the 3600 seconds in the hour a joule of work has been expended, making a total of 3600 joules; therefore 3600 joules is a watt-hour and the latter is a definite amount of work and not a rate of work as has often been supposed.

The watt-hour has often been with gross impropriety called a watt and electricity is often said to cost so much per thousand watts when watt-hours is meant. The rate of energy that a circuit consumes in watts can be obtained by taking simultaneous readings of a voltmeter and ammeter properly connected and multiplying the results together. A wattmeter which directly indicates the watts at once may be used. If we desire the watt-hours that a circuit consumes in a given length of time, we must take the average watts absorbed during that period and multiply by the number of hours.

Thus we may calibrate a recording wattmeter by connecting the instrument together with voltmeter and ammeter as shown in Fig. 1. Here *W* represents the wattmeter, *V* the voltmeter and *A* the ammeter. *R* is a resistance which absorbs the energy. Such a test should be conducted as follows:

The initial reading of the wattmeter should be taken and the current turned on. Simultaneous readings of the voltmeter and ammeter should be taken every minute, and the test should last at least half an hour. The simultaneous readings should be multiplied together and their average taken. At the close of the run the wattmeter should be read again and the difference between the new reading and the initial reading obtained. The average of the products of the voltmeter and ammeter readings multiplied by the time of the run in hours should equal the difference of the two wattmeter readings.

If alternating currents are used, the voltmeter-ammeter method will be worthless if the load resistance is at all inductive; a wattmeter can be used, but that is not always accurate, and, in fact, if any such instruments are used in either alternating or direct-current calibration tests, they must be newly and carefully standardized. A standard method which requires no such artificial references is desirable. This is provided by the calorimetric method, which briefly is as follows:

Whatever energy be consumed in the circuit, *R* (Fig. 1), provided it is a simple resistance, is measured by the heat it emits, whether the current be alternating or direct and the resistance inductive or non-inductive. This heat can be conveniently measured in what is known as an ice calorimeter. Such an instrument is shown in Fig. 2. It consists of a wooden box of suitable size, in which is placed a metal box, suitably supported on legs within the wooden one. The

metal box has a conical or pyramidal bottom, so that it can be drained to the last drop through the outlet at the apex of the pyramid. In this inner box is placed a metal receptacle containing the substance, the heat of which is to be measured, in this case, the resistance, *R*. This resistance is only shown in diagram in Fig. 2; it should consist of wire strung back and forth on a wooden frame within a metal receptacle. This metal box carrying its resistance is placed in the inner box of the calorimeter and packed with dry, clean ice. The large wooden box is also packed with ice in order that the only melting influence on the inner ice shall be the heat proceeding from the box containing the resistance.

Having thus packed the calorimeter and properly connected the wattmeter to be tested to the circuit, there must be a delay till the box containing the resistance has cooled to o C. and the drip from the box containing it has practically ceased. The receptacle for receiving the water should then be carefully wiped out dry, weighed and placed under the drip once more. The wattmeter should then be read and at a noted time the current should be turned on. Water will immediately begin to drip, and great care should be exercised to avoid loss by spilling or evaporation. The receptacle should be kept covered. The test should be continued for several hours. The current should then be cnt off and the apparatus be allowed to cool to o C. once more when the drip will cease. The wattmeter reading should then be noted and the water should be accurately weighed. The following will then be true:

The heat energy of the resistance was used in melting the ice, and the weight of water just obtained is that of the ice so melted. To melt 1 lb. of ice 36,000 calories of heat are necessary, which are equal to 150,120 joules or, dividing by 3600, to 41.7 watt-hours. We therefore multiply the weight of the water in pounds by 41.7 and thus obtain the actual number of watt-hours consumed, which is what the wattmeter should read.

LESSONS IN PRACTICAL ELECTRICITY

THE SINE CURVE. LAG DUE TO INDUCTANCE.

In first taking up the study of alternating currents, the student is apt to run up against a mathematical phraseology which is rather perplexing. Even to those who have encountered the same terms in the study of mathematics, their constant application in the statement of purely physical phenomena may be none the less mystifying, particularly when he learns, for example, that it is only by careful design that the rate of variation of an alternating current can be made to approximate to the sine law, whose employment gives rise to the phraseology in question.

Prof. Joubert showed in 1881 that in a particular form of alternator with which he experimented, the variation of E. M. F. followed a sine law. The alternator nappened to be one without iron in its armature, and it was thus by mere accident that the curve which he obtained approached so nearly to a sine curve. Had he experimented with another type of alternator, he might have obtained a curve differing very widely from this, with the result, possibly, that the branch of alternating currents would not have been so largely invaded by mathematicians, and explanations of its phenomena might therefore have been established more on a physical basis.

As modern alternators are constructed, certain conditions have to be very carefully observed in their design in order that they may give a current whose variation will approximate to that of the sine law, it being necessary to this end to carefully proportion the shape of pole-pieces, air gap, armature teeth (if any), and the disposition of windings. It is now known that a sine curve variation of alternating current is the best in most cases, for the reason that the inductance is a minimum with such a variation; also, since a motor should conform with the dynamo running it, a standard form of current variation is desirable, and the sine curve offers the most natural solution. It is well, therefore, for the student to understand how the sine curve is related to alternating E. M. F. and current.

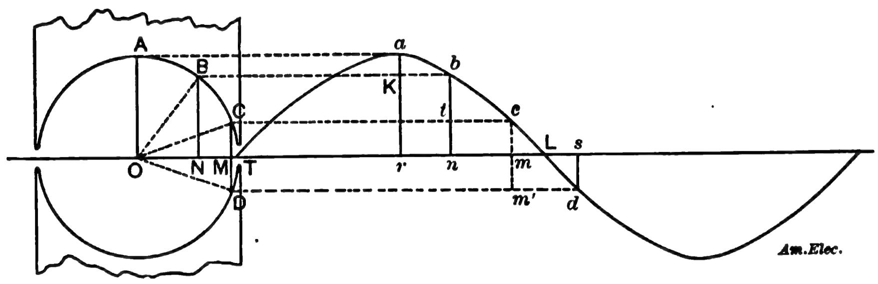


FIG. 1.—THE SINE CURVE.

Referring to Fig. 1, on the left is a representation of a bipolar dynamo having a perfectly uniform field in the air gap, the lines of force passing through the armature in a vertical direction. It is evident that when a conductor is at *A*, it is cutting the lines at right angles, while when it becomes horizontal or reaches the pole gap, its direction of motion being parallel to the lines of force, none will be cut; at any intermediate position, such as *B* or *C*, the lines of force are cut at an angle, so that a conductor in passing over the same distance will cut fewer lines at *B* than at *A*, and still fewer at *C*.

Let us now assume that in cutting through a very small distance at *A*, the number of lines cut is proportional to the length of the line, *A O*; then it could be very easily shown (Lessons, October) that in passing through the same distance at *B*, the number of lines cut will be proportional to *B N*, and at *C* to *C M*; while, as stated before, no lines will be cut when the conductor arrives in the middle of the pole gap. Considering now *A B C* as a circle, if the value of *A O* is taken as unity, then the line, *B N*, will be the sine of the angle, *B O N*, and the line, *C M*, the sine of the angle, *C O M*. We thus see how the term "sine" is introduced in the generation of an alternating E. M. F., for in a field such as here considered, the E. M. F., when a conductor is at any point, is proportional to the sine of the angle of the conductor at that point.

If we lay off above a horizontal line, lines such as *a r*, *b n* and *e m*, at a distance apart proportional to the angular distance between the several lines, we will obtain a curve such as that shown, known as a sine curve. In this case the distance, *TL*, is equal to the length of a semi-circumference of the circle at the right, and the distances, *rn*, *n m* and *m L*, are equal to the circular arcs, *A B*, *B C* and *C T*. By dividing up the whole circle in a large number of parts, we may thus plot the complete sine curve shown, which corresponds to a complete revolution of a conductor.

It will be seen that in the case of a bipolar dynamo such a curve will only be generated if the field in the air gap is absolutely uniform in every part, and if the revolutions of the conductor are also uniform. In the case of a multipolar alternator the conditions are not so simple, it being necessary for the designer, as stated above, to carefully proportion the field-pole area, air gap and windings to produce such a curve. In what follows we will assume that the variation of E. M. F. follows that of a sine curve, but this hypothesis is not necessary for the understanding of the phenomena that will be treated, as they could be just as well explained if the variation of E. M. F. differed very considerably from that of a sine curve, though the construction of the curves would be much more complicated.

The next subject that will be taken up is that of lag, or difference of phase between the alternating E. M. F. and current of a line having inductance. Suppose (Fig. 2) that in a line carrying alternating current there is introduced an inductance which, in this case, is a coil *A B*, having an iron core; if the current were continuous it would set

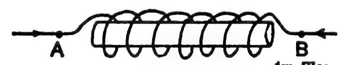


FIG. 2.—INDUCTIVE COIL.

up in the iron the number of lines of force, depending upon the strength of the current, the magnetic quality of the iron and the number of turns in the coil, and no effect would be produced on the circuit beyond that due to the simple ohmic resistance of the coil.

In the case of an alternating current, however, since its value is being constantly varied, the number of lines of force will, of course, also vary, there being at any instant a larger or smaller number than at another instant. We can consider when lines of force are changing, that if added they cut

through the coil in order to enter; and if lines are subtracted they cut through the coil in order to pass out.

We know that if any circuit is cut by lines of force, an E. M. F. is set up in it. In the case of dynamos, the conductors are moveable and cut stationary lines of force. In the case above referred to, the conductor, on the contrary, is stationary while the lines of force are movable, but the same results follow from the cutting of lines of force—an E. M. F. being set up.

Referring to Fig. 1, it will be seen that while the current has varied from the value which it has at a to that which it has at b, the change is $a K$; in varying from the value at b to the value at c, the change is $b l$, while in varying from the value at c to that at d, the change is $c m'$.

As the distances $r n$, $n m$ and $m s$ represent time or parts of a revolution, it will be seen that in a given time the decrease or increase in current is much less at such a point as a, than it is at such a point as at L. If a large number of lines were drawn, it would be shown that near a the variation is least and very slow, while at L it is a maximum. Consequently, when the value of an alternating current passing through the coil of Fig. 2 is at its maximum, the least number of lines of force are in a given time *changed* in the coil; while when the value of the current is passing through zero (as from C to D, Fig. 1), the *change* in the number of lines is greatest. Consequently the number of cuttings of the coil, and therefore the inductive E. M. F. set up, will be least when the value of the current is a maximum and will be greatest when the value of the current is a minimum.

Referring now to Fig. 3, suppose that the value of the current passing through the coil is represented by the curve, M; then the back or inductive E. M. F, which it sets up in the coil will be zero at b and s and a maximum at g and K. As the rate of variation of the curve, M, follows the sine law, the form of the inductive curve, N, must also necessarily follow the sine law, as the number of lines which pass in and out of the coil vary during the given intervals according to this law, and the amount of the inductive E. M. F. depends upon the rate of this variation. The maximum value, Kg, of this inductive E. M. F. will depend upon the inductance or henrys of the coil in Fig. 2; if, for example, the alternating current has a frequency, n, of 60 and the inductance, L is .1 henry, and the value of the current, C, flowing is one ampere, the effective inductive E. M. F. will be $2 \pi n C L$ or 37.7 volts; the maximum E. M. F. or $g K$, will be this quantity divided by .707 or about 53 volts. (The relation between effective and maximum E. M. F. will be explained in another article.)

It is interesting to note the analogy between this case and the counter E. M. F. in a continuous-current motor. In the latter case, as the armature revolves its conductors cut the lines of force in the air gap, thereby creating a counter E. M. F. which acts against the E. M. F. at the binding post of the motor. In the case of Fig. 2, the alternating current sets up an inductive E. M. F. which has a similar action, the coil in fact, being a generator of E. M. F. In other words, an inductance placed in an alternating circuit produces an effect similar to that of the revolving conductors of a continuous-current motor, in both cases an E. M. F. being generated.

Suppose we have a continuous-current motor with 110-volts at the binding post, in which a counter E. M. F. of 100 volts is set up. We thus have a free E. M. F. of only 110—100 = 10-volts. If the resistance of the armature is, say, .1 ohm this will permit 100 amperes to flow through it, while if there were no counter E. M. F. present, $110 \div .1 = 1100$ amperes would pass through it. We thus see that the counter E. M. F. in the motor serves to choke back the current that would otherwise flow. The case is analogous with that of the alternating-current phenomenon under consideration, such a coil as that shown in Fig. 2 usually being called a choking coil. There is this very important difference, however, that in the case of the continuous-current motor we merely add the numerical value of the counter E. M. F. directly to the value of the free E. M. F. in order to obtain the E. M. F. at the binding post, or the impressed E. M. F. In the case of alternating currents, on the other hand, as will be seen by reference to Fig. 3, this cannot be done on account of the shape of the curves, for at some parts of the curves the E. M. Fs. thus represented are subtractive and at others are additive. The effect of this condition will now be considered.

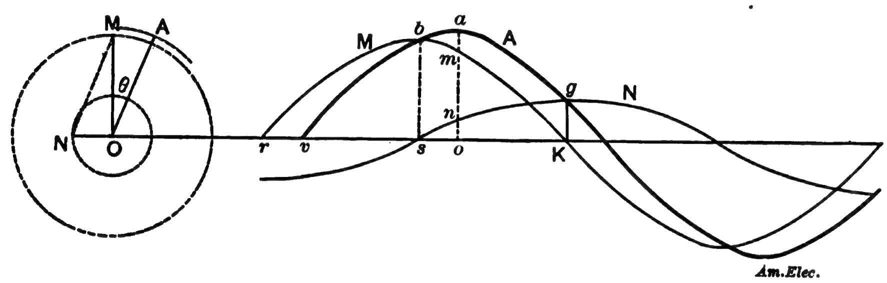


FIG. 3.—IMPRESSED, FREE AND INDUCTIVE E. M. F. CURVES.

We have assumed that the curve, M, represents the current flowing through the coil; we will further assume that the same curve represents the free E. M. F. corresponding to the 10 volts in the case of the continuous-current motor, or the E. M. F. corresponding to the current passing. This implies that the free E. M. F. and the current will be in phase; that is to say, when the current is at its maximum or minimum value, the free E. M. F. will have its maximum or minimum value. In any practical case both the E. M. F. and current would not be represented by the same curve to the same scale, since this implies that they have the same numerical value; but we can imagine that there are two scales, such that if the maximum E. M. F. is ten times greater than the maximum current its scale will be one-tenth as great, the result of which will be to make the two curves coincide. This enables us to represent, as stated above, both the current and the free E. M. F. by a single curve, since both of these are in phase.

As in the case of the continuous-current motor, this free E. M. F. is the difference between the E. M. F. at the binding posts, $A B$ (Fig. 2), and the inductive E. M. F. represented by the curve, N. Therefore, in order to obtain the curve of the E. M. F. at the binding post, the curves, M and N, must be combined. This, of course, is very simply done, as it is merely necessary, for example, to add the ordinate, $n o$, to the ordinate, $m o$, thus giving the ordinate, $a o$; proceeding in this way we finally get the curve in heavy line, which represents the E. M. F. that will be measured by a voltmeter between the points, A and B (Fig. 2).

It will be seen that the curve of current, M, and the curve of the E. M. F. at the binding post, called the impressed E. M. F., do not reach their maximum or minimum values at the same time; for example, the impressed E. M. F. curve reaches its maximum value at a, and the current-curve, M, at b, while the former has a minimum value at v, and the latter a minimum value at r. As the horizontal line represents time or part of a revolution, the curve E. M. F. does not reach its minimum value until a period of time later than the impressed E. M F., represented by the distance, $r v$; that is to say, the current curve lags behind the curve of impressed E. M. F.

We thus see that introducing the inductance, $A B$, in the alternating circuit has resulted in throwing the current-curve out of phase with the impressed E. M. F; or, in other words, the current and E. M. F reach corresponding values at different instants of time, or at different parts of the revolution of the armature, the amount of this difference being a constant.

Referring to the circles to the left of Fig. 3, suppose $O M$ to represent the maximum value of the free E. M. F; then it will be seen that the E. M. F. corresponding to the curve, N, would be generated by a conductor, $O N$, at right angles to the conductor, $O M$, and moving in a field of force weaker than that at M in the ratio of $O N$ to $O M$. The impressed E. M. F., being the resultant of the free E. M. F. and of the inductive E. M. F., may be found by the parallelogram of forces, which gives for it a maximum value, $O A$. In other words, the impressed E. M. F. would be generated at the same time as M and N by the conductor at A moving in a field of force stronger than that at M in the ratio of $A O$ to $M O$. The angle between the two conductors, $M O$ and $A O$, is called the *angle of lag*, and corresponds to the interval of time, $r v$, on the horizontal line. Moreover, the angle, $M O N$, being a right angle, it is said that the curve of the inductive E. M. F. is *in quadrature* with the current to which it is due, or differs from it *in phase* by 90 degs.

It will be seen that the conceptions of angle of lag and of E. M. F. in quadrature

with the current inducing it, are highly artificial. They are useful, however, in mathematical demonst.ation of alternating-current phenomena, and also generally in expressing effects set up in an alternating-current circuit containing inductance. The simplest manner, however, to look at the cases under consideration seems to be that indicated above.

That is, to resume, the variation of E. M. F. in any coil or loop in a circuit carrying alternating current causes lines of force to enter into, and leave the coil or loop, thereby setting up an inductive E. M. F. in the same manner that a counter E. M. F. is set up in a motor. In a continuous-current motor the E. M. F. at the binding post, or the impressed E. M. F., is the resultant of the counter E. M. F. and free E. M. F., the resultant in this case being the arithmetical sum. Similarly, in the case of an inductance, the impressed E. M. F. is the resultant of the free E. M. F. and the inductive E. M. F.; in the case of alternating currents, however, on account of the changing value of both these factors,a lag is produced, or the impressed E. M. E. and current do not reach similar values at the same instant. In the former case, we have merely, arithmetically, to add the counter E. M. F. and free E. M. F. to get the impressed E. M. F.; in the latter case it is necessary to lay down several curves and then measure off the time by which the current and E. M. F. are displaced, or go through a very complicated analytical operation to arrive at the desired result.

It will thus be seen that difficulties must be expected to be encountered in the study of alternating currents from the nature of the phenomena involved, which make it impossible to approach the simplicity of explanation and of calculation of continuous-current phenomena. The subject has, however, been made much more difficult than it really is by a treatment founded on the mathematical properties of the sine curve rather than upon the physical nature of alternating currents.

Letters on Practical Subjects

An Improved Battery Jar. Wire Joints for Light Currents.

To the Editor of American Electrician :

For some time I have been trying to get manufacturers of cylinder-carbon batteries to have a jar made with a slight depression in the center of the bottom to hold zincs in place and also to contain a few drops of mercury for the purpose of keeping the zincs amalgamated and clean. I have been using a small glass salt-holder for this purpose two years, and find a great advantage in it. There is one other little "short cut" I have been using for five years to great advantage, which may be new to some. It is the employment of tin-foil in making electrical joints for bell or other light current work. I first make a good twisted joint, then cover it with tin-foil and over this wrap good tape. I have often used this in cases of emergency in making electric light connections and have found it better than a poor soldered joint.

Memphis, Tenn. JAS. D. RANDALL.

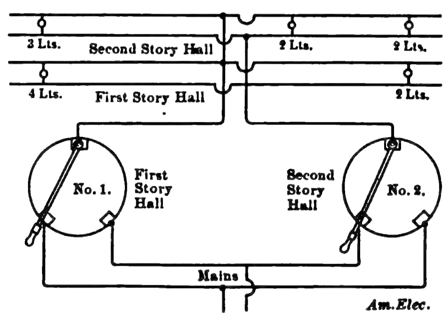
Incandescent Lamp Switch Circuit.

To the Editor of American Electrician :

I see in the June number a query by "S. K. P," concerning a switch and circuit that will enable incandescent lights to be turned on or off at either switch without one interfering with the other.

The accompanying diagram illustrates a method used by the writer, which has been installed in four residences and proven very satisfactory.

The diagram almost explains itself. The switch lever is fastened to the top connection on the base, from which one side of the line proceeds to the lights; the lever swings to either right or left to make connections with the mains. For instance, suppose a person leaves the first floor and changes the position of the lever of switch No. 1 from left to right. which will extinguish the lights. If, then, another person changes the position of the lever of switch No. 2, the lights come up. There is, of course, no chance of a short circuit, the lights being either on the lamps or broken. When this circuit was first used, I could not find a switch that suited, so I made the one shown, but now switches can be found on the market for this kind of work.



INCANDESCENT LAMP SWITCH CIRCUIT.

JAS. C. CONNAUGHTON.
Kansas City, Mo.

Calculating Circular Mils of Conductors.

To the Editor of American Electrician :

The following method of calculating the circular mils of wires may be of interest to some or your readers, as it enables the cross-sectional area of any wire to be obtained, if but the circular mils of any single size of wire in the B. & S. series are known.

Knowing the size of one wire, the circular mils of the next larger size may be obtained by multiplying by 1.261, and of the second size larger by multiplying by 1.59; the third size larger is, of course, double in the B. & S. gauge.

To determine the circular mils of the next size smaller, multiply by .793, and by .629 for the second size smaller, the third size smaller having one-half the number of circular mils.

As an example, suppose it is remembered that the circular mils of a No. 0000 wire are 211,600, and that it is desired to know the circular mils of a No. 8 wire. The cross-sectional area of a No. 0 wire is one-half of 211,600, or 105,800 circ. mils; of a No. 3 wire, one-half of this, or 52,900 circ. mils, and of a No. 6 wire, one-half of the latter, or 26,450 circ. mils. The circular mils of the No. 8 wire are, therefore, $.629 \times 26{,}450 = 16{,}637$ circ. mils.

By the above method, practically the exact circular mils are obtained in passing from one wire to the first or second wire on either side. In passing down from No. 0000, a slight error is introduced, which, however, is negligible in practice. For example, the actual circular mils of a No. 8 wire are 16,510, while the size as above calculated is 16,637 circ. mils.

The above numbers may perhaps be more easily remembered as approximate percentages. That is, increase the circular mils by 59 per cent. or 26 per cent.; to decrease, take 80 per cent. or 63 per cent. of the circular mils.

Chicago, Ill. CHAS. P. PARNELL.

The Effects of Low Voltage On Motor Circuits.

To the Editor of American Electrician:

It is a fact well known among street railway men that low voltage on the line is harder on the motors than if the voltage is maintained at 500 or over. Some of us are inclined to ascribe as the reason, that when the voltage is low, more current must pass through the motors, and as the wires in the motors are not large enough to carry this increased current, the motors heat and give trouble.

This explanation is a very natural one and is in one sense of the word correct, but we must not fall into an error of thought. It, no doubt, originated from a knowledge that a given electrical horse power can be imparted to a car in any combination of volts and amperes, the only condition being that the product of the two shall equal the number of watts corresponding to the given horse power.

Thus, 500 volts $\times$ 20 amperes = 10,000 watts; also, 200 volts $\times$ 50 amperes = 10,000 watts, both combinations corresponding to an electrical HP = 13.4; but sight must not be lost of the fact that on a car of given weight we have no control over the amount of horse power which a given voltage will cause it to absorb. This is governed by the design and gearing of the motors, and the only way we can increase the current which a given car will take at a given voltage is to increase the mechanical load. The motors themselves, by means of their C. E. M. Fs. automatically regulate the current by a speed response to all variations in voltage.

If on a certain section of a given system the voltage is kept at 500 or more, a car will take, on a level, a certain amount of current, absorb a certain amount of energy, and run at a certain speed; on a section where the

voltage is lower, say 400, the current will remain nearly the same, but since speed depends upon the voltage applied, the speed will be proportionally lower and so will the energy absorbed by the car. (400 volts × current, instead of 500 volts × current.)

We see then, that at 400 volts, the car takes less energy from the line and also gives out less mechanically than at 500 volts, assuming the controller to be properly handled in both cases. We have just used the expression "properly handled," and this is the saving phrase for those who claim that increased troubles which attend abnormally low line voltage are due to motors taking more current. The motors do not of themselves take more current, and moreover, there are other motor losses that are less at the lower voltage and speed than at the higher, so that on the whole, with the same weight of car to draw, the motors properly handled would heat less at the lower voltage.

As a rule, the running time on roads is made out on a 500-volt speed basis and with very little margin for exceptionally busy hours, and although increased traffic and road extension may pull the line voltage at parts down from 10 per cent. to 50 per cent., the cases of reducing the time table accordingly are rare. The fact of the matter is, that in order to make his time, the motorman is compelled to throw the controller handle around much faster at starting than would be necessary if the voltage were normal, thus giving the speed no chance to respond to the increase in current. This, coupled to the fact that with a time table unsuited to the voltage, current notches must be used, when, under proper conditions, the car should be "coasting along" with the current off, actually does increase the average daily current and heat the motors abnormally.

With a time table suited to the voltage, the motor repair bill would actually be less on a lower voltage circuit, because the insulation would be subjected to less breaking down strain; but in adopting such a system, more cars would be necessary to meet the same requirements, and more cars would mean higher first cost, more attendance and greater loss in transmission.

There is no doubt, however, in the writer's mind but that there are many roads where it would be profitable to at least increase the running time.

Buffalo, N. Y., S. L. CLEVELAND.

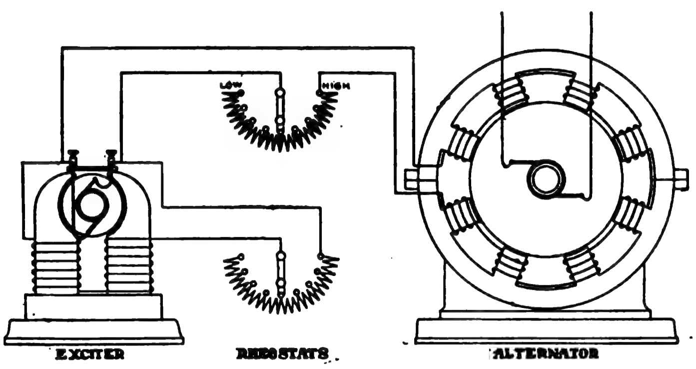


FIG. 1.—EXCITER WITH TWO RHEOSTATS IN CIRCUIT.

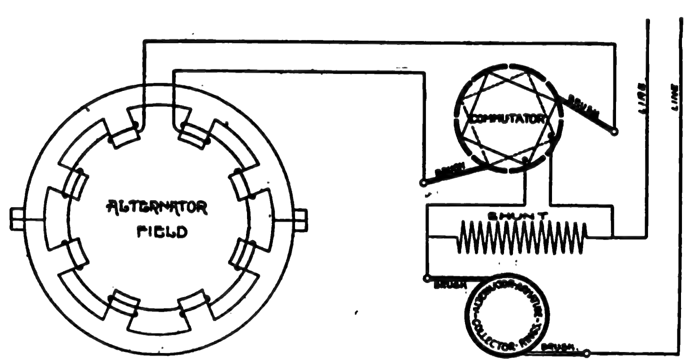


FIG. 2.—ADJUSTABLE SHUNT ON RECTIFIER.

ELECTRICAL CATECHISM

140. How may the voltage of an alternator be regulated?

By varying the rate of change of the number of lines of force passing through the armature coils. The general principles are similar to those for the regulation of direct-current machines, for which see catechism in *Electrical Industries* April, 1896, page 107, and AMERICAN ELECTRICIAN May, 1896, page 29. The methods applicable to alternators are variation of the number of active armature wires and variation of the field strength.

141. How can the number of active wires be changed in the armature of an alternator?

This cannot be done by shifting the main brushes as with arc-light machines, since they bear upon solid collecting rings and the position of the brushes is determined simply by convenience. The only practical way is to cut out some of the coils by a switch or its equivalent, a method easily applied to alternators having stationary armatures.

142. In what ways may the field strength of an alternator be changed?

By varying the current through the field coils. The other methods sometimes used with continuous-current machines, namely, of varying the number of turns in the field coils or of changing the reluctance of the magnetic circuit, are not generally applicable because of the large number of poles in the alternator field.

143. In what ways may the field current of an alternator be changed?

By varying the voltage of the exciter dynamo, by varying the resistance in the alternator field circuit and also, if the machine is of the composite type, by varying the current through the rectifier and series coils.

144. How is the voltage of the exciter varied?

In the Heisler machines formerly used for series incandescent lighting, the exciter was a series dynamo, the voltage of the exciter and consequently the current through the alternator field being regulated entirely by shifting the brushes, a method common with arc-light dynamos. A similar method was used with some European alternators. It is more common to use a shunt dynamo for the exciter and to control its voltage by a rheostat in the field circuit. When the same exciter is liable to be required for more than one alternator, it is customary to have a second rheostat in the field circuit of each alternator, as suggested in Fig. 1, the voltage of the alternator being raised when resistence is cut out of either rheostat.

145. What is an alternator of the composite type?

A composite alternator is similar to a compound-wound, continous dynamo in that it has two field windings. In addition to the regular field coils which carry the main magnetizing current from the exciter, there is a second winding upon two or upon all of the pole-pieces, carrying a rectified current from the alternator. The rectified current is proportional to the current from the alternator and so strengthens the field to balance the losses in the machine and also, if so desired, the losses on the line.

146. How is the alternating current rectified?

The alternator shaft carries a commutator having as many segments as there are poles in the field. Alternate bars are coupled and brushes are adjusted so that both change simultaneously from one set of bars to the other. When the commutator is connected to the armature circuit the brushes may be adjusted so as to change from one set of bars to the other at the same instant when the armature current changes direction. The brushes will then take off a current that is pulsating, but always in the same direction.

147. How is the rectifier connected into the circuit?

Sometimes it is connected directly in series with the armature, one set of commutator segments being connected directly to one end of the armature winding, while the other set of bars is connected to the outside circuit through a collecting ring and brush. Sometimes an adjustable shunt is connected around the commutator as suggested in Fig. 2, so that only part of the current is rectified. In other cases, the whole current is rectified, but only part goes through the field coils while the remainder goes through an adjustable shunt. Sometimes the current for the commutator is taken from the secondary of a transformer attached to the armature spider and having its primary connected in series with the armature windings; this scheme is to avoid having the field coils connected with the high-voltage circuit.

QUERIES AND ANSWERS

Please give the dimensions of a spark coil.
H. K.

Make a core ¾ in. in diameter and 8½ ins. long of annealed soft iron wire of the smallest size available. Form a spool by slipping on each end of the core a disk of ½ in. wood 2½ ins. in diameter. Tape the core and wind on seven layers of No. 14 cotton-covered magnet wire, for which about 3½ lbs. will be required. Tape the coil and wind on neatly a layer of twine, and then shellac.

1°. How are currents of very high frequency obtained? 2°. Please give the construction of a high-frequency alternator of a frequency of 500,000 volts.
C. K.

1°. By means of a spark or disruptive gap, such as that of an induction coil; in the latter case the two ends of the circuit would connect near the two sparking points. 2°. A machine of such a voltage has never been made and never will be. High voltages are obtained by means of special transformers. A coil for high voltages and frequencies is described in the issue for August, 1896.

Please state if an alternating-current circuit of from 3000 to 10,000 volts with a frequency of 60, would affect a telegraph circuit 25 to 40 ft. distant, the two circuits running parallel for about 6 to 8 miles?
J. R. S.

The electromagnetic disturbing effect of a variable current depends upon the current flowing and not upon the voltage. It is improbable in the case mentioned that there will be sufficient inductive effect to interfere with the working of ordinary telegraphic apparatus. Should there be any, it can be very simply obviated by a few transpositions of the alternating-current line.

1°. What should be the dimensions of a screw propeller for a boat weighing 115 lbs. and the capacity of a motor to run the same at about 6 miles per hour? 2°. How many storage batteries would be required to run the boat for four or five hours? 3°. Please give the construction of a motor for above boat.
R. B.

1°. A propeller 1 ft. in diameter with 9 ins. pitch running at 850 r. p. m., run by a half-horse power motor. 2°. Three 150-ampere-hour cells will be required for each two hours. 3°. The construction of a half-horse power motor will be described in an early issue.

What are the number of alternations and the frequency of an alternator having ten poles and running 1500 r. p. m.?
T. D. H.

The alternations are the product of the number of poles by the speed, and the frequency half of the amount thus found. In the present case the alternations are 15,000 per minute and the frequency 125 per second, the frequency being the complete number of cycles per second. To develop a complete cycle any armature conductor must pass through a distance equal to that between two poles of the same polarity.

What are the elements in an Edison-Lalande cell?
F. A. B.

The positive element is zinc—usually two zinc plates, between which is the negative element. The latter consists of a conglomerate plate of black oxide of copper, which may be made by heating a sheet of copper, removing the scale which results and compressing it in the form of a thick plate; this plate is held in the cell in a frame of copper. The electrolyte is a 40 per cent. solution of caustic potash or soda. A layer of petroleum is usually supplied to the surface of the solution to protect it from the atmosphere.

Is a low voltage on a railway circuit (say 200 volts drop) detrimental to the motors? Should motors be in series or in parallel over such portions of the road where the voltage is low?
H. D. C.

A low voltage cannot be directly detrimental to a motor, as the motor's action depends only upon the current which passes through it, and it "can have no knowledge" if the voltage is high or low. Indirectly it can be detrimental through the motors being kept in parallel when they otherwise would be in series, the larger current thus passing heating the machines; this point, however, should be proved by trial before being accepted. This latter consideration will determine the answer to the second question.

How is the candle-power of an arc light found?
J. N. S.

By means of a photometer (such as the one whose construction is described in the October issue), measure the light given out at different angles, both below and above the horizontal, and take the mean of the candle-powers thus found; this will give the true or spherical candle-power of the arc, which is usually less than a third of the rated candle-power. The rated candle-power is supposed to be the candle-power of the strongest ray, or in the case of a continuous-current arc, the one making an angle of about 45 degs. below the horizontal. The National Electric Light Association has defined a 2000-CP arc lamp as a lamp requiring 450 watts, or 10 amperes at 45 volts between the arc.

1°. Why is the resistance of bridging bells increased with the number in circuit? 2°. How should grounded telephone lines be transposed to prevent cross-talk?
M. L. C.

1°. The resistance is increased approximately in proportion to the number of bells in order to keep the total resistance of the circuit from being reduced. 2°. Transposition of grounded telephone lines will not obviate cross-talk, as half each circuit is identical, being the earth. The lines should be kept as far apart as possible so that as few as possible of the electromagnetic lines of force of one wire may enter between the wire of the other circuit and the ground, and that electrostatic induction, which varies as the square of the distance, may be reduced to a minimum. By placing one of the grounded wires underneath the other, some of the lines of force of each circuit will be neutralized with respect to the other, and the cross-talk correspondingly reduced.

In a transformer, why does the secondary E. M. F. and current bear a certain ratio to the primary E. M. F. and current?
SUB.

Assuming there are no losses, on open circuit both primary and secondary enclose the same number of lines of force at any instant, and as the current varies in value, each of the two coils is cut by the same number of lines, and, therefore, their E. M. Fs. will be proportional to the turns, since the total number of cuttings will be in this ratio. When current is taken from the secondary, this current sets up lines of force opposing those of the primary, and the lines thus "killed" are supplied by more current flowing into the primary. Aside from this explanation, from the law of conservation of energy, the primary energy must equal the secondary energy (leaving aside losses); and since the two voltages are assumed to remain constant, the primary and secondary currents must increase or decrease together.

What size core and wire should be used in making a strong straight electromagnet to be operated by 15 cells of dry battery?
G. K.

The winding to give maximum strength should be such as to have a resistance equal to that of internal resistance of the battery, all cells being in series. To determine the internal resistance, first short-circuit the cells through an ammeter; suppose the reading is 4 amperes. Assuming the voltage of each cell as 1.45, the total voltage of the 15 cells in series will be 22.75 volts. From Ohm's law we find the internal resistance of the 15 cells to be $22.75 \div 4 = 5.69$ ohms, which is the resistance of the wire to be used and which should be of the largest size practicable. If of No. 22 wire, 300 ft. will be of this resistance. In this case, with a 1½ in. cylindrical, soft iron core, 8 ins. long, there would be three layers of that wire. For lifting purposes it would be best to bend the core horse-shoe shape, or divide it into two pieces connected by a yoke. As the current from dry cells quickly falls off, this type should not be used where the circuit is to be closed any length of time.

How is the value of the magnetic field of a dynamo or motor found?
G. J.

1°. From the formula

$$N = \frac{F}{R} \left(\text{webers} = \frac{\text{gilberts}}{\text{oersteds}} \right),$$

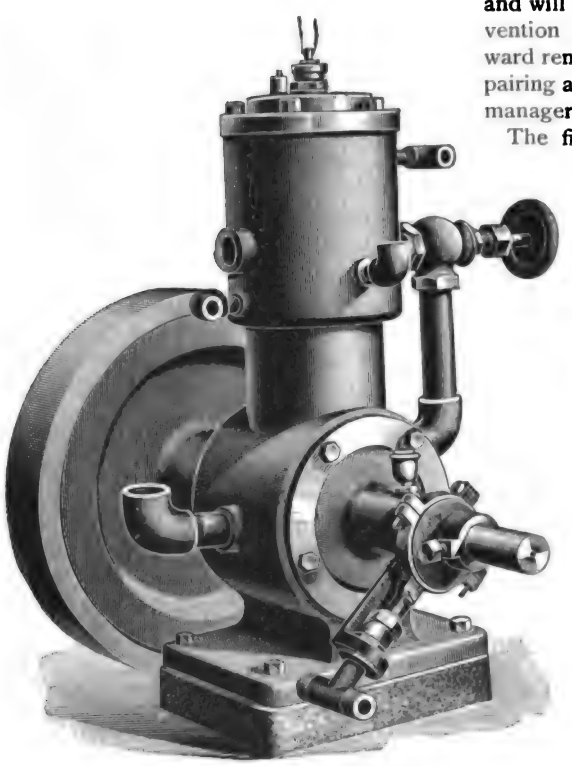
F being the magnetomotive force and R the reluctance of the magnetic circuit. To find F, multiply the current in the field by the number of turns and by 1.257. To find R it is necessary to know the geometrical dimensions of the circuit. The reluctance in the air gap is 1 oersted per square inch area and 1 in. length, being, of course, one-tenth, say, of this for 10 ins. area; the reluctance of the iron depends upon the magnetic quality and degree of saturation, being usually less than that of the same area and length of air usually in the proportion of 500-1400 for wrought iron and 250-700 for cast iron. It should be borne in mind that the reluctance is, say, ten times as great for a length of 10 ins., and one-tenth for a cross-section of 10 sq. ins. The amount thus calculated should be decreased by from 10 to 50 per cent. for leakage. 2°. If E is the E. M. F. of a dynamo on open circuit, A the total number of armature conductors and r the number of revolutions per second, then the total number, N, of lines in the gap is $\frac{E}{rA} \times 10^8$; 10^8 is unity followed by eight zeros, or 100,000,000. From 1°. it will be seen that the accurate calculation of electrical machinery requires a full knowledge of the magnetic circuit and good designing judgment.

New Apparatus and Appliances.

ONE HORSE POWER GAS MOTOR.

The accompanying engraving illustrates a new type of gas motor suitable for running light machinery. As shown in the cut, the motor is arranged for marine propulsion with the use of gasoline, and the same design may be used for a light motor carriage. The capacity in each case is about 1 H P. The weight of the marine engine is 135 lbs., and of the stationary type, 200 lbs. The height of the stationary engine is 23 ins. and that of the marine is 17 ins. The height from the base to the center of the shaft is, in each case, 4½ ins. The marine type will propel a 16 or 18-ft. boat, and will run in either direction.

A pump is used to circulate water in the water jacket of the engine illustrated. In the stationary form a tank is used instead of a pump. These motors are built on the two-cycle compression system, with an impulse at each revolution of the crank. The charge is received and exhausted through a cylinder port opened and closed by the movement of the piston. A suitable valve regulates the charge received from the closed crank chamber in which the mixture is compressed by the downward stroke of the piston, and thoroughly mixed by the motion of the crank. The engraving shows the circulating pump, but the pipe leading from the pump to the water jacket is omitted.



ONE HORSE POWER GAS MOTOR.

The motor described has recently been brought out by the Palmer Electric Company, Mianus, Conn., and is supplied complete, or the castings with working drawings are furnished to amateurs and others desiring to construct the engine.

RENEWING INCANDESCENT LAMPS.

The process of renewing burned-out incandescent lamps as developed by Mr. E. F. Dwyer, president of the Lynn Incandescent Lamp Company, is of so much interest that we give below a description of the same, together with a view of the testing room, where all lamps receive a thorough test before being placed in stock.

The first operation is to test the burned lamp for vacuum, as it is found that quite a few contain some air, and which are thrown out on the supposition that the bulb is defective; as all bulbs have stood the test of actual service, the probability of failure from the cause noted is therefore less than with new lamps.

The bulbs are next sorted into their several sizes in order to be fitted with a filament that would look well in the bulb, the coil type being used in the short bulbs, and the loop type in the long bulbs. After this the tips of the lamps are removed with a file, and the opening enlarged to about the diameter of a lead pencil. Through this opening the old filament is removed, and the new one inserted. It is then cemented into position by a cement which is a good conductor, and will stand a high temperature. The invention of this paste was the first step toward rendering possible the business of repairing a lamp, and is due to the company's manager.

The filament used is different from anything used by other companies. It has a very high specific resistance, and requires a very thick surface of flashed carbon. This filament is also well adapted to 220-volt lamps, and the company is now designing a high-voltage lamp which it is confident will prove superior to any yet made.

The flashing process is carried on in chambers having an extremely high vacuum. This is obtained by a special mechanical pump of the company's own design, mercury pumps not being used. The company has found that the quality of this flashed surface depends to a great extent on the degree of vacuum, the higher the vacuum, the more homogeneous and smoother the resulting carbon. A point is also made to have a large percentage of the filament of deposited carbon.

The next operation after mounting the filament, is to clean the bulb of the black deposits from previous use. This is accomplished by revolving the lamp in a suitable holder in large gas burners, which effectually remove every trace of blackening from the bulbs. Immediately following this operation, a small glass tube is fused to the opening made in the bulb, through which the air is drawn by a system of pumps.

The lamps are exhausted one at a time and the entire attention of the operator is given to one lamp until it is finished. When the lamp is exhausted to the satisfaction of the operator, a small blow pipe flame is directed upon the tube which is melted into a point—a perfect counterpart of the tip of the original lamp. The lamp is now ready to be measured on the photometer for candle power and voltage. The lamps are sorted, all lamps of one voltage and efficiency being placed together, and after going through the usual tests, are washed, labeled and wrapped ready for shipment or stock.

TESTING ROOM, LYNN FACTORY.

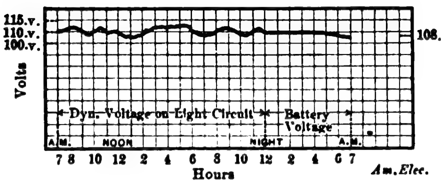
OLD STORAGE BATTERIES REPAIRED.

About eight years ago a storage battery plant of 112 cells of 250 ampere-hours capacity was installed at the family residence of Mr. Potter Palmer and also 114 cells of the same type at the Palmer House. These batteries have now been in use for about eight years and are considered among the oldest plants in America, and their long life is doubtless due to the small holes in the elements containing the active material, which holes are about ¼ in. square. About six months ago one series (56 cells) of the old battery plant at the Palmer residence was removed, being considered useless owing to the small amount of active material left in the plates. This plant after a while was taken from the junk pile, loaded on a dray and delivered at the Palmer House; there the small amount of active matter left in the elements was removed, and the plates put under heavy pressure and straightened out. After all the positive plates went through this operation, they were then repasted, and the surface was also coated with active material, thus practically nothing but active matter being exposed. The negative elements were found

to be in first-class condition and requiring no attention.

The positive and negative elements were then assembled and each positive plate was enveloped in an insulation in the form of card-board about ⅛ in. thick. This insulation binds the active material in place, allows the free circulation of the electrolyte or solution, withstands the sulphuric acid, does not allow the plates to swell and buckle, and consequently renders the cells as good, if not better, than new. The elements so repaired now occupy about one-third the original space, being banded with large rubber bands in a very compact form.

The insulation used in this battery plant is



LIGHTING AND BATTERY LOAD CURVE.

an electro-chemically treated substance, in the form of a gray card-board, and it has been in use by the Haschke Storage Battery Company, for about three years.

This insulating medium, which is a secret process and prepared personally by Mr. Haschke at his laboratory, is used in his own battery or to renew or overhaul a battery that has been manufactured by a concern no longer in existence. The overhauling of the Palmer House plant was under Mr. Haschke's personal supervision.

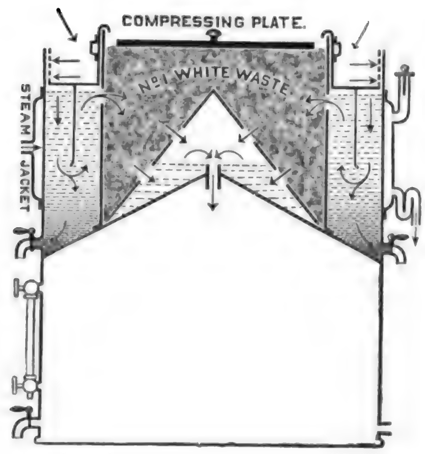
The entire system of annunciators, bells, fire-alarms and watch-man's clock service at the Palmer House are now being operated by eight cells of small storage battery of 20 ampere-hours capacity, displacing about 35 primary batteries. The accompanying curve (plotted from the record of a Bristol recording gauge) represents the regulation of the lighting load obtained through the use of a storage battery. This battery consists of 55 cells of 250 ampere-hours capacity, the discharge being 130 amperes at midnight and 25 amperes at 7 A. M.

Messrs. Roth Bros. & Company, 30 Market Street, Chicago, are sole manufacturers of the Haschke storage battery. Information concerning overhauling old batteries, will be given by J. E. Haschke, cor. Ashland Boulevard and Ogden Avenue, Chicago.

WASTE OIL REFINER AND PURIFIER.

The waste oil refiner and purifier illustrated herewith is an apparatus constructed on correct principles throughout, each of the various parts performing a definite function, as will be seen from the description and illustration.

The waste oil is poured into the upper annular chamber, whence it passes through a fine strainer (which is removable for cleaning) into the lower or refining chamber. This latter chamber has a baffling plate, as shown, and is surrounded by a steam jacket. The oil passes from the strainer against the hot outside wall of the refining chamber and then down to its bottom in such a manner that the unsettled oil is always kept away from the filtering material by a deflecting shield. The oil being heated, is made bright and clear and the impurities together with entrained water are separated and settle to the bottom of the chamber, whence they are withdrawn through the dirt faucets. The oil settles in the refining chamber 12



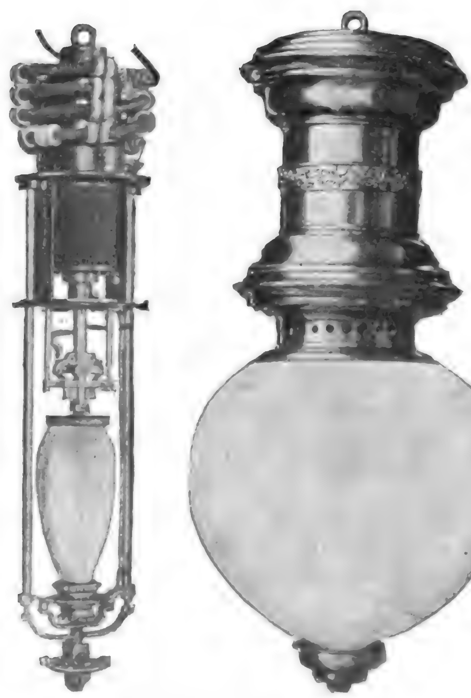
WASTE OIL REFINER AND PURIFIER.

hours and is practically clean before it begins to filter through the compressed white waste in the center compartment; it finally passes through a muslin cover over the perforated cone by capillary attraction into the clear oil compartment, from which it is delivered cold.

The above oil filter, known as the "Famous," is made by the Famous Filter Company, 205 South Main Street, St. Louis, Mo.

ENCLOSED ARC LAMPS.

The existence of a demand for a short arc lamp for vestibules, hallways and restaurants and in places where the ceilings are low has led the General Electric Company to design a single-solenoid lamp to meet it, which is shown in the accompanying illustration. This lamp is ornamental in appearance and measures only 2 ft. in length over all. It is designed for use on 110-volt circuit, the potential at the arc being 80 volts. As in many cases for interior lighting a short ornamental lamp is desired, not giving as strong an illumination as the standard 5-ampere lamps, this lamp is also built to burn at 3 amperes with 3-8 in. carbons and a carbon life of 75 hours.



ENCLOSED ARC LAMP.

The lamp mechanism consists of one magnetic spool or solenoid which attracts through its center a tubular armature surrounding a brass tube through which the upper carbon is fed. To the lower end of the tube is attached a clutch which grips the carbon itself instead of the carbon rod. The upward pull of the solenoid is cushioned in two air dash-pots at the top of the tube. This gives a steady lift to the upper carbon, which can drop instantly when released.

The current is taken by the carbon from a brass tube with a contact device consisting of a series of flat springs pressing upon the interior of the tube. The contact device slides freely in the tube and gives perfect contact in all positions. When trimming the lamp the upper carbon is pushed up into a spring clip in the contact device where it is held accurately without set-screw or clamp.

The 5-ampere lamp has a carbon life of 100 hours and uses $\frac{7}{16}$ inch carbons. It is provided with three loops in the spool winding by means of which the lamp may be adapted to 4, 4½ or 5 amperes as desired. The 5-ampere lamp is similar in appearance to the 3-ampere lamp and can also be fitted with weatherproof casing for outdoor service.

IMPROVED GRAVITY CELL.

The cell shown herewith is of the Daniell type but with a number of improvements which reduce the internal resistance, increase the economy and life, and make the cell more constant, reliable and cleanly.

IMPROVED GRAVITY CELL.

The porous cup shown, which contains the zinc element, is supported by its rim resting on the upper edge of the jar, its bottom

thus being a horizontal porous partition between the liquids, the gravity principle being retained. The cup is closely surrounded by the cylindrical copper, which is supported by cross pieces below the cup. The internal resistance of the cell is thus reduced while, since the zinc solution is confined to the porous cup, the copper will not be destroyed, as would be the case in the ordinary gravity cell if it extended above the zinc line.

The cell has a sealed cover, which entirely prevents evaporation and the creeping of salts, so that no attention is required until the sulphate of copper is exhausted. The zinc, which rests on the bottom of the porous cup, is made of large size, lasting from 12 to 15 months, and does not need cleaning.

The Gethins improved gravity battery is especially adapted for charging storage batteries for light power, and for use direct for telegraph, telephone or signal work. It is made by the Burnham-Gethins Company, 181 Tremont Street, Boston.

Factory Electrical Power Equipment.—In a paper read before the American Society of Mechanical Engineers, Prof. D. C. Jackson summarizes the question as follows: In constructing new manufacturing plants, the extra first cost of a complete system of electrical transmission for the works is negligibly small (except under exceptional circumstances) compared with the annual saving effected by its means when its advantages are properly utilized. In certain industries the advantages of electrical transmission outweigh the first cost of making a change from mechanical to electrical transmission in established plants, while in many plants where this condition would not commonly exist, the arrangement of buildings or the growth of the plant is frequently of a character with reference to the prime power-plant, which places electrical transmission upon an advantageous footing, either as an auxiliary to the main transmission or as a rival to the existing mechanical transmission. All large tools or machines, such as use from 5 or 7½ HP and over, should be supplied with individual motors, while smaller tools or machines requiring less power should be grouped and driven from motor-driven shafts. These groups should ordinarily be arranged so that a motor of not less than from 3 to 5 HP capacity is required, and not more than from 10 to 15 HP. The grouping of tools, the subdivision of power, and the manner of delivering power of motors to driven machinery is a matter which can be given only the most general treatment as a whole, as each industry includes conditions of its own which must be taken into the count. Observation indicates that some manufacturers who are using electrical power failed to carefully weigh the question of its subdivision when preparing to install their plant, and have thereby lost much of the advantage which may be derived from the electrical transmission.

PERSONAL.

Mr. Henry Lewis has severed his connection with the Standard Telephone Company, of Philadelphia. Mr. A. M. Rose, chief electrician of the same company, has also resigned.

Mr. C. A. Boyd, who has been connected with the Walker Company at its works in Cleveland, for some time past, was recently appointed superintendent of the entire shops. The recognition is well deserved, as Mr. Boyd, although young in years, is known to be one of the brightest and most competent engineers in the country.

Mr. Eugene E. Bogart, doing business under the name of A. L. Bogart, at 22 Union Square, New York City, died on the morning of June 24, from the result of injuries received from being thrown from a cable car in New York City, on Feb. 5, this year. Mr. Bogart succeeded to the business of Abraham L. Bogart, his father, who died suddenly July 25, 1896.

Mr. Percy Martin, of the Union Electricitats Gesellschaft, Berlin, Germany, recently returned to Europe after a short visit. Mr. Martin, who was formerly at Schenectady with the General Electric Company, has for some time been connected with the engineering staff of the Union Electricitats Gesellschaft, which company has installed many of the European electric railways, and has obtained the contract for the extensive Berlin electric traction system.

Mr. C. B. Ellicott has been appointed City Electrician of Chicago, replacing Prof. J. P. Barrett, resigned. Mr. Ellicott is well known among electrical engineers, having for the past seven years been with the Western Electric Company, and for four years superintendent of construction of that company. The ability and experience of Mr. Ellicott insure that the city electrical interests will be properly cared for. The Chicago electrical department maintained the leading position which it always occupied under the able management of Prof. Barrett.

Mr. C. H. Wilmerding, whose resignation from the Chicago Edison Company was recently announced, has opened an office in the Old Colony Building, Chicago. Mr. Wilmerding, as already published, will engage in electrical engineering, his practical experience having specially qualified him for this line of work. In addition to his engineering business, he has also accepted the general Western management for the Crocker-Wheeler Electric Company, which has just opened an office in Chicago Mr. Wilmerding will both conduct the business affairs of this company in the West, and do the engineering work required in connection therewith. The AMERICAN ELECTRICIAN extends congratulations and wishes him a full measure of success in the line of work he has undertaken.

Mr. Geo. F. Porter has accepted from Mr. W. R. Brixey the general agency of Day's Kerite insulated wires, cables and tape, and entered upon his new duties at 203 Broadway immediately after the Niagara Convention. Secretary for many years of the National Electric Light Assaciation Mr. Porter is one of the best known members of the electric light fraternity in the United States, and his geniality has led to a most desirable popularity among all with whom he has come into contact. The insistence with which the members of the National Electric Light Association at Niagara waylaid and appealed to Mr. Porter not to resign the secretaryship was highly complimentary to his personal and business qualities. As a compromise, Mr. Porter will watch over the secretaryship until a successor is found. Mr. F. G. Fuller, a pioneer in the electrical field, and formerly identified with Kerite, will assist Mr. Porter in his new duties.

Mr. William Leonard Madgen, of London *Lightning*, sailed for England July 1 at the end of a month's visit to the United States, in the company of Mr. Arthur Wright, electrical engineer of the Brighton, England, central station. Mr. Madgen attended the Niagara Convention, in which he was naturally much interested, having headed a movement in England which resulted last year in the first meeting there of the Association of English Municipal Electric Lighting Engineers, an organization somewhat similar to the National Electric Light Association. *Lightning*, of which Mr. Madgen is the founder and one of the principal proprietors, is the organ of British central station men, and one of the most successful technical journals in Europe. After the Niagara Convention Mr. Madgen with Mr. Wright visited the West and New England on trips of inspection to the most important central stations and electrical manufacturing establishments, in order to inform themselves concerning American electrical engineering and manufacturing methods.

Mr. Alfred H. Gibbings, whose article on 220-volt lamps in the Souvenir issue of the AMERICAN ELECTRICIAN, attracted much attention at the Niagara convention, is one of the younger leaders of the electrical engineering profession in Great Britain. During 1883 to 1889 he studied under Profs. Ayrton and S. P. Thompson, while serving an apprenticeship with a firm of mechanical engineers. Commencing the latter year, he superintended the erection of various electrical works, including a large copper electro-deposition plant and the marine lighting plant of a large ocean steamship, and subsequently superintended the laying of mains of one of the large London electric lighting companies. From 1892 to 1893 Mr. Gibbings was electrical engineer to the Hove Commissioners; in 1893 he received the appointment of borough electrical engineer of Hull, and two years later resigned to accept a similar position to the Corporation of Bradford, where he has remained since. Mr. Gibbings is the author of a large number of papers read before various scientific and technical societies, and also of many contributions to the electrical and engineering journals. He has been one of the champions of high-voltage incandescent lamps, and largely aided in their rapid introduction in Great Britain.

NEW BOOK.

THE ELECTRIC TELEPHONE. By Edwin J. Houston and A. E. Kennelly. New York: The W. J. Johnston Company. 412 pages, 143 illustrations. Price, $1.

As a descriptive work on the telephone this book will be welcomed both by the general public and by electricians who, while not caring for a strictly technical treatise on the subject, yet wish to know the general principles applying in telephony, and the details of the more important apparatus employed in its practice. The chapters are as follows: Introductory; Elementary Acoustic Principles; Elementary Electrical Principles; The Telephone Receiver; The Microphone Transmitter; The Induction Coil; Call Bells and Batteries; Single-Circuit Connections; Multiple-Circuit Connections; Isolated-Station Switchboards; Multiple Switchboards; Telephonic Circuits; Long Distance Telephony; Radiophony and Miscellaneous. As will be seen, the subject is thoroughly covered, and the clearly written text and numerous illustrations make its understanding a matter of ease.

TRADE PUBLICATIONS.

Gas Engines. The Weber Gas & Gasoline Engine Company, of Kansas City, Mo., has issued a forty-eight page, oblong catalogue devoted to its engine, which is illustrated as applied in many different ways, as for hoisting, irrigation, electric lighting, ice making, agricultural purposes, etc.

Telephones. Catalogue No. 4 of the Farr Telephone & Construction Supply Company contains eighty-four pages of matter, relating principally to telephones and telephone supplies. Telephones for every purpose are illustrated, together with exchange and line supplies. A number of pages are also devoted to house goods.

Switches. A new catalogue of the Hart & Hegeman Company, Hartford, Conn., shows a number of changes and additions that have largely enhanced the value of their well known line of switches. Among other matter of technical interest we notice diagrams of circuits for two, three and four-way switches. One of these is for a four way and two three-way switches, which enable a group of lights to be controlled from three points.

Electrical Repairs and Supplies. In a large-size 92 page catalogue, A. K. Warren & Company, 451 Greenwich Street, New York, show every description of article employed in electrical work, from the generator to the lamp, and from the motor to the source of supply, only the newest and latest material being catalogued. In addition, attention is called to the repair business of the firm, which includes the repair of every description of motor and dynamo parts.

Steam Pumps. The new catalogue of the Snow Pump Works, Buffalo, N. Y., contains 113 pages and more than three score illustrations of steam pumps of every variety of type and size. A sectional view

enables the principle of the Snow pump to be easily learned, while the various half-tone illustrations form almost, if not altogether, a pictorial representation of the entire art of steam pumping. Among the views given are several of triple-expansion pumping engines.

Dynamos and Motors. The Triumph Electric Company, Cincinnati, O., has issued a handsomely printed and illustrated catalogue of its line of dynamos and motors, which includes direct-current machinery—both belted and direct-connected—for isolated plants, central stations, power houses, power transmission, ship lighting and, in fact, for every use to which such machinery can be put. The illustrations are extremely well executed and the text has been carefully prepared, the object evidently having been to produce a work of such value as to insure its preservation.

Arc Lamps. Catalogue No. 11 of the General Incandescent Arc Lamp Company sustains the reputation of this firm as the publisher of exceptionally handsome trade literature. The cover is of thick crinkled paper which sets off the title to excellent advantage. All of the standard and new types of Bergmann arc lamps—both open and enclosed arcs—are illustrated and described. A number of ornamental brackets are illustrated, and some of the pages are devoted to panels and switch-boards, wiring fittings, and a complete line of switches, includinga clock switch, ground detector or switches. etc.

BUSINESS NEWS.

Mr. C. H. Florandin, export agent and manager of advertising department C. & C. Electric Company, New York, sailed for Europe Saturday June 19, on a trip combining pleasure with business.

Ball Engines.—The Ball Engine Company, Erie, Pa., is building two 125-HP horizontal, tandem compound engines which will be used for the electric transmission of power and light in a large works in the City of Moscow, Russia.

Mr. Fred. F. Fischer, designer of the Fischer, Fischer-Gates and Gates automatic engines, and until recently chief engineer and head salesman of the steam department of the Gates Iron Works, has withdrawn from this company, and will probably in the near future place upon the market the improved Fischer engine, which it is intended shall embody the experience gained in designing and operating the above-named engines.

Mr. W. W. Burnham, for fifteen years with the Electric Gas Lighting Company of which he was four years manager, has joined forces with Mr. Jas. L. Gethins, of battery fame, under the firm name of the Burnham-Gethins Company. The new company will make a specialty of primary and storage batter, ies, and their storage battery outfit, consisting of the improved Gethins battery and storage cells, is already meeting with gratifying success, being particularly well esteemed by physicians.

McIntosh, Seymour & Company, of Auburn. New York, have opened a New York office in Havemeyer Building, room 1222, which will be in charge of Mr. E. A. Merrill. Mr. Merrill has been identified with the former New York sales agency of McIntosh & Seymour engines for the past four or five years, and is widely known as the author of "Electric Lighting Specifications" and "Reference Book of Tables and Formulas for Electric Railway Engineers" both of which works have passed into a second edition.

The Buffington-Osburn Manufacturing Company, 171 Canal Street, Chicago, has recently purchased, and is now the sole manufacturer of, the Crowdus & Bates primary battery. This company has equipped entirely a new plant for the manufacture of this apparatus, and is prepared to fill orders without delay. This battery is already very favorably known to the trade, as there are over 3000 in use at present, and it secured the World's Fair award in 1893 for the best primary battery exhibited, The vast number of testimonials of the merit of this battery is also a very strong argument in its favor.

Mr. F. M. Hawkins, late manager of New York office of the Electric Engineering & Supply Company, Syracuse, N. Y., has accepted a position as general Eastern sales agent for Crouse-Hinds Electric Company, and Pass & Seymour, both of Syracuse, N. Y., with offices at 39 Cortlandt Street, N. Y. A full line of porcelain specialties and knife switches, etc., will be carried in this office. Mr. Hawkins has been with the Electric Engineering & Supply Company since its organization in 1889, occupying the above position for the past three years; previously he was in the Thomson-Houston Company. Mr. Hawkins is well known to the trade and is deservedly popular. The Crouse-Hinds Electric Company and Pass & Seymour are to be congratulated upon the acquisition to its forces of so capable and popular a man.

The Phœnix Iron Works Company, of Meadville Pa., has just received an order from its agents in Japan for a compound engine, this being the second order for a compound and the fourth engine sold there in the past six months, as well as two boilers for Shanghai, China. The same company has just installed the following plants: For the Fostoria (O.) Incandescent Lamp Company, a 125-HP compound engine and pair of boilers; the new Asylum at Polk (Pa.), three compound engines; Rapid Railway. Detroit, one 400-HP, direct-connected and two 250-HP, belted compound engines and three boilers; Oakland Railway (Detroit), two 150-HP, simple engines and two boilers; Jacksonville (Fla.), one 150-HP, compound engine; Massachusetts Charitable Mechanics Association, Boston, one 100-HP, direct-connected, simple engine; Bureau of Engraving & Printing, Washington (D. C.), two 150-HP simple engines; Salamander Works, Woodbridge (N. J.), one 125-HP simple engine; Syracuse (N.Y.) Gas Company, two 40-HP simple engines and two Manning boilers; Odell Manufacturing Company, Groveton (N.Y.) one 100-HP simple engine; McKees Rocks (Pa.) Electric Light Company, two 125-HP compound engines and two boilers; Lincoln (Ill.) Water, Light & Power Company, two 175-HP compound engines and three boilers; Pittsburg (Kan.) Railway, one 250-HP and one 150-HP simple engines and three boilers; Conneaut Lake Exposition Park, one 80-HP simple engineand one boiler. Orders have been received the past week for over 1000-HP boilers, most of them of special construction for high pressures.

Rheostats. Among the electrical concerns of the West rapidly pushing its way to the front is the Cutler-Hammer Manufacturing Company, of Chicago. This concern was started by Harry H. Cutler, of Boston, Mass., and Edward W. Hammer, of Chicago, during the financial panic of 1893, before the opening of the World's Fair. They rented a small machine shop, and started in to revolutionize the rheostat business. At this time rheostats were generally built by stretching wire coils inside of a wooden box with brass buttons on the front. While it is true that fire-proof rheostats were being made at that time, the Cutler-Hammer Manufacturing Company was the first to push the introduction of fire-proof starting boxes, provided with the magnetic release. They purchased the patents covering this invention, and brought out many original and valuable improvements which were promptly copied by others. The product of this company is too well known to require any description, and the management feels confident that it can easily maintain its past reputation of supplying the standard of excellence in rheostats, and keep ahead of all those who depend on imitating it. Mr. Hammer severed his connection with the company last January. Its present officers are Harry H. Cutler, president and treasurer; Frank W. Smith, vice-president, and Irving Usner, secretary. Mr. Harry Cutler graduated from the Massachusetts Institute of Technology in 1881, and has been constantly engaged in electrical work ever since, being well known as an able and successful electrical engineer. Mr. Smith is a graduate of Troy Polytechnic Institute, and has had a long practical mechanical experience. Mr. Usner is a graduate of Rose Polytechnic, and is well versed in the management of the office of a large concern. Mr. Horace S. Smith, one of the largest stockholders, was for many years connected with the Illinois Steel Company as general manager, superintendent and consulting engineer. The concern is active, aggressive and bound to succeed, and holds an enviable position among the electrical industries of the country.

The Westinghouse Electric & Manufacturing Company, on Tuesday, June 22, 1897, declared a quarterly dividend on its preferred stock of 1¾ per cent. On Wednesday, the annual meeting of the stockholders took place at the factory of the company in East Pittsburgh, Pa. The annual report of the company was read, showing the condition of the company to be a prosperous one. The same board of directors of last year were re-elected, composed of August Belmont, Lemuel Bannister, Geo. Hebard, Henry B. Hyde, Marcellus Hartley, A. M. Byers, N. W. Bumstead, Chas. Francis Adams, Brayton Ives and Geo. Westinghouse, Jr. After the meeting an announcement was made to the stockholders of the company of the largest contract for electrical apparatus, which has ever been given out, and which was secured by the Westinghouse Electric & Manufacturing Company, last Saturday. This was a contract from the St. Lawrence Construction Company, of New York, for fifteen 5000-HP generators, which are to be erected at their plant at Massena, northern New York, and involving about three-quarters of a million dollars. This contract, together with that recently given by the Cataract Construction Company, of New York, for five 5000-HP generators for installation at Niagara Falls, N. Y., makes the total of twenty 5000-HP generators, having a total capacity of 100,000 HP, which has been ordered from the Westinghouse Electric & Manufacturing Company this year. The five generators for Niagara Falls are well under construction and the other fifteen required by the St. Lawrence Company will be immediately proceeded with and their construction will give employment to a large number of men. These orders cover only the apparatus for generating electricity, and there will necessarily be required other apparatus of equal capacity for the utilization of the electrical energy produced by these great generators, and the Westinghouse officials expect that a large proportion of the additional apparatus will be ordered from their company by reason of its having secured the contract for the principal apparatus. The placing of these recent important contracts has undoubtedly resulted by reason of the great success of their three 5000-HP generators already installed at Niagara Falls, coupled with the fact that the Westinghouse Electric & Manufacturing Company has the only establishment where such large work can be turned out proper and satisfactorily.

ELECTRIC LIGHT CONVENTION NOTES.

Mr. John C. Boss, of Elkhart, Ind., was on hand to keep the Lakon transformer in evidence.

Mr. M. R. Rodigues, of Brooklyn, was on hand with a line of battery fan motors, forming the only exhibition of the kind at the convention.

The Bibber-White Company, of Boston, was on hand in the person of its energetic treasurer, Mr. C. E. Bibber, whom all seemed to know and welcome.

Sterling Insulating Varnish was represented by Mr. W. Elliot, in whose care the interests of the Sterling Varnish Company, of Pittsburgh, did not suffer.

Mr. Franklin S. Terry, of the Sunbeam Lamp Company, Chicago, though arriving a day late, took full advantage of the occasion in favor of the Sunbeam lamp.

The New York Insulated Wire Company had two hustling representatives in Mr. P. H. Hoover, from the New York office, and Mr. Jas. Woolf, from the Chicago office.

Mr. Hugo Reisinger, was at home, at least in name, among central station men, and his "Electra" carbon needed still less of an introduction than himself.

Okonite was kept to the fore by Capt. W. L. Candee and Mr. George T. Manson. Visitors to Okonite headquarters received as a souvenir a lead pencil in the form of a key.

The Forest City Electric Company, of Cleveland, distributed one of the most appreciated pamphlets at the convention—a well written and printed treatise on rail bonding.

Mr. T. I. McLeod, had much to say concerning the Kinsman desk lamp manufactured by his company, McLeod, Ward & Company, New York, bnt found few who had not already known the "Kinsman."

The Mitchell Tempered Copper Company, of Corry, Pa., showed specimens of its highly-conductive copper castings for electrical purposes, Messrs. Mitchell and Ruhl doing the honors of the occasion.

Mr. W. W. Low, president of the Electric Appliance Company, was a prominent representative of the electrical supply branch at the convention, and presented to visitors a neat game counter as a souvenir.

The Hart & Hegeman Company, of Hartford, was represented by Mr. A. H. Pease, who brought up to date the information of delegates on Hart switches.

The Buckeye Lamp Company, Cleveland, had an exhibit of Buckeye lamps of all shapes and candle powers. The interests of the company were looked after by Messrs. Bailey Whipple, J. R. Massey and E. L. Nash.

Mr. Jas. P. McQuaide circulated among the delegates to refresh their memory on the merits of the wares of the National Conduit & Manufacturing Company—conduits and cables alternately furnishing a theme.

The Diamond Electric Company, of Peoria, Ill., had an interesting exhibit in charge of Messrs. G. A. Scheeffer and Wm. Wilson, consisting of the Scheeffer wattmeter and transformer and Cardew earthing device.

The Phœnix Glass Company, New York, had on exhibition its "Glad Hand," which unique indicating device will undoubtedly have an immense sale. Mr. E. H. Reck looked after the interests of the Phœnix Company.

Mr. I. E. Adams was in charge of the exhibit of the Adams-Bagnall Company, of Cleveland, and was kept pretty constantly engaged in explaining the features of the Adams-Bagnall arc lamp to appreciative audiences.

Mr. John T. McRoy, of Chicago, who can give pointers to any of the professional "adsmiths" in the preparation of advertising literature, was in evidence, and McRoy conduit, it is needless to say, was kept well to the fore.

Mr. J. P. Williams, 9 Cortlandt Street, New York, had on exhibition a complete line of Paragon fans, with which was displayed the effective announcement "This entire exhibit sold to the Chicago Edison Company."

The Phillips Insulated Wire Company, of Pawtucket, R. I., was represented by Mr. H. C. Adams, Jr., its secretary. Mr. Adams added no small quota to the ever-increasing prestige of the "old and reliable" company he represented.

The Standard Underground Cable Company, had in attendance Messrs. G. L. Wiley, T. E. Hughes of the New York office, who presided in one of the exhibition rooms over a complete exhibit of Standard cables, wire and tape.

Mr. George A. McKinlock and Mr. H. B. Adams, of the Central Electric Company, of Chicago, as representatives of the supply interests, saw that the manufacturers did not monopolize too great a share of the attention of the convention.

The Bryant Electric Company had an energetic and capable representation in Messrs. Bryant, Eaton, Scribner and Grier, who allowed no delegate to leave Niagara until he had been interviewed by by one or more of the Bryant contingent.

The Keystone Electrical Instrument Company, of Philadelphia, was fortunate in the selection of its representative at the convention, for few could escape recognizing the merits of its instruments after Mr. Elmer P. Morris had set them forth.

The Interior Conduit & Insulation Company, was represented by Mr. V. Clarence Durland who was one of the fortunates not obliged to do missionary work, as interior conduit and Lundell apparatus are among the staples of the electric lighting trade.

Mr. Albert B. Herrick, of Herrick & Burke, New York, was in much requisition for information on knotty points connected with central station details, particularly those relating to switch-boards, on which he is the recognized American authority.

Mr. R. S. Hale, of Boston, though not a regular attendant at electric light conventions, needed no introduction, his writings on power generation being familiar to central station men. Mr. Hale was present in the interests of the Wright demand meter.

The Electric Storage Battery Company was represented by its general manager, Mr. Edward Lloyd, from whom many central station men obtained valuable information at first hand on the subject daily becoming more important—how to reduce the load peak.

The Puritan Arc Lamp Company had a working exhibit of Puritan lamps in front of the hotel, and the mechanism of a new series enclosed arc lamp attracted attention inside. Messrs. Stewart Wise and Malcolm H. Baker, had charge of the interests of the company.

Pass & Seymour, of Syracuse, were represented by Messrs. Pass & Seymour and an exhibit of their porcelain fittings. Those not already posted were made aware of the fact that this firm takes the lead of the world in the successful manufacture of difficult shapes of porcelain.

Mr. Thos. W. Flood, Commissioner of Wires of Boston, was a welcome visitor to the convention. Many members were acquainted with the admirable manner in which the Boston city wire department is conducted, and all were glad of the opportunity to meet its affable chief.

The Safety Insulated Wire Company, of New York, through its general manager, Mr. Leonard Requa, was much in evidence, and force was added to Mr. Requa's claims for safety wire by the announcement of a large contract from the city of Detroit for underground cables.

The Cutter Electrical & Manufacturing Company, Philadelphia, had its interests in charge of Messrs. Cutter and Kirkland, who found that little explanation was necessary concerning the merits of I. T. E. circuit breakers and motor starters, which have everywhere become well known.

H. M. Underwood & Company, of Chicago, had several of its specialties on exhibition in charge of Mr. H. M. Underwood. Among those was the Cloos junction box, which unites the functions of a street connection box and a switch-board, and which attracted much favorable attention.

L. A. Chase & Company were represented by their general manager, Mr. S. B. Condit, who was kept busy showing a complete line of Chase junction boxes and couplings, and, with the assistance of the inventor, Mr. L. L. Elden, explaining the merits of the Elden alternating-current circuit-breaker.

Mr. Robert Corey, was, as usual, in attendance and not lacking in the geniality that for a decade or more has made him the foremost favorite at electrical gatherings. Mr. Corey saw that Simplex wire, Columbia incandescent lamps and Bergmann arc lamps were not kept in the background.

The Belknap Motor Company, of Portland, Me., had on exhibition the Chapman voltage regulator, the inventor, Mr. W. H. Chapman, explaining its features. This apparatus seems to fill the long-felt need of a dynamo regulator which will regulate without in itself demanding constant regulation.

Gale's Compound for commutators had an energetic advocate in Mr. M. J. Isaacs, business manager of the manufacturer, K. McLennan & Company, Chicago. A successful trial of the compound for several days on machines in the Westinghouse exhibit convinced any who may have doubted its merits.

Mr. B. E. Greene was one of the familiar faces about the convention. Though he has left the electrical fold his trip to Niagara is evidence that, like many others who have entered another field, he is still under the magical influence that electricity continues to exert over those who have once been her subjects.

Mr. C. C. Gartlan, of 370 Maryland Street, Buffalo, N. Y., exhibited an extremely compact and handsomely made arc dynamo regulator of fine mechanical appearance, adapted to the Brush dynamo. The device is claimed to be a great improvement, both electrically and mechanically, over the older types of regulators.

The Standard Paint Company was represented by Mr. H. W. Benedict, of the New York office of the firm, and Mr. F. S. Howard of the Chicago office. A new brand of tape was shown to those interested and some tastily executed literature distributed. A handsome souvenir in the shape of an X-ray pocket book was much in demand.

The Crouse-Hinds Electric Company, of Syracuse, N. Y., was represented by Messrs. H. B. Crouse and Jesse L. Hinds, who found that their switches and switch-board material required little missionary work, being already well known to those present. The Hinds patent tubular switch attracted particular attention.

The Eddy Electric Manufacturing Company, of Windsor, Conn., was represented by Mr. A. D. Newton, assisted by Messrs. S. M. Blake and John A. Stewart. The Eddy Company is one of the few electrical concerns that prospers regardless of the general business situation, being "always in it," as one of the delegates at Niagara remarked.

The Shaumut Fuse Wire Company, of Boston had its interests well looked after by Mr. H. P. Moore, who showed to visitors a complete exhibit of fuse wires and a line of Linton & Southwick switches, which type has been endorsed by the Boston Underwriters' Association. O. C. White's, adjustable holders for incandescent lamps were also shown in this exhibit.

Mr. Alfred A. Thresher, president of the Thresher Electric Company, Dayton, O., was a principal representative of a branch of electrical development now taking on large proportions—direct-connected electric power equipment. Mr. Thresher confined his exhibits to a collection of views of direct-connected pumping and printing and other plants recently installed by his company.

Mr. W. C. Woodward, manager of the Providence Electric Light & Power Company, exhibited a new type of fuse of his invention, made by the D. & W. Fuse Company, of Providence. The fuse wire being surrounded by an insulating material which does not conduct heat, is reliable and instantaneous in action. A much-sought-for souvenir was a D. & W. fibre fuse case containing a cigar of excellent brand.

The Diehl Electric Manufacturing Company, of Elizabethport, N. J., was well represented by Mr. E. H. Bennett, president, and Mr. B. C. Kenyon, manager of the sales department. The geniality of Messrs. Bennett and Kenyon added largely to the list of friends of the Diehl Company, and their expositions of the merits of Diehl apparatus lost nothing by observance of tact in introducing the subject.

The Western Electric Company had on exhibition a number of its numerous types of fan motors, in charge of Mr. C. D. Wilkson. Included was a column fan and incandescent-light fixture which presented a neat appearance, and, by the addition of a circular table, its usefulness was extended. Other representatives of the company present were Messrs. S. A. Chase, T. G. Grier and Edward Rockafellow.

The Fort Wayne Electrical Corporation was represented by its electrical engineer, Mr. J. J. Wood, and by Mr. Thos. Duncan from Fort Wayne, and Messrs. Philbrook, Wonder, Knight and Lott, of the sales department. The handsomest catalogue distributed at the convention was that of the Fort Wayne Corporation, among whose other literature was a lithographic engraving in colors of a 3000-light "Wood" compound alternator.

The Partrick & Carter Company, of Philadelphia, was represented by Messrs. E. Ward Wilkins and Thomas L. Townsend, the latter being the doyen of electrical traveling men. An exhibit of some of the latest P. & C. apparatus and appliances occupied a conspicuous position, but which would have had attention attracted to it anywhere, as well from the merit of the wares shown as from the striking business mottos displayed on the booth.

Mr. E. G. Bernard, of the E. G. Bernard Company, Troy, N. Y., as one of the pioneers in electric lighting and as a present manufacturer of the most modern types of apparatus and appliances, found himself at home equally with the new comers and the old timers. With the latter he exchanged reminiscences of the day of wood lamp sockets and fuse boxes; and to all he gave advance information of a new line of multipolars soon to be put on the market by his company.

Mr. J. P. Cummings, president, and Mr. J. F. Austin looked after the interests of the Cummings underground conduit. Mr. Cummings is one of the most popular of convention visitors, and the recent removal of his headquarters to Pittsburgh brings another strong force into the Eastern field. Many of the delegates took advantage of the opportunity to inspect the visible portion of the Armorite conduit installed at Niagara, which has been carrying high-tension mains for two years without a fault.

Mr. Herbert May, one of the most popular of convention visitors, represented the Electrical Engineering & Supply Company, of Syracuse, N. Y. The announcement subsequent to the meeting of the convention of the failure of the well known Syracuse company has been received with real personal regret. The mark "E. E. & S." had become so familiar throughout the United States that sympathy will everywhere be felt for the company in its troubles, from which it is hoped it will successfully emerge.

Mr. W. F. Bossert represented the Bossert Electric Construction Company, of Syracuse, which dis-

played a number of its appliances and fittings, all of which had the excellent mechanical appearance distinctive of Bossert manufactures. An electromagnetic switch attracted much attention, both from the excellence of its contact parts and its self-locking feature, which prevent the switch from being opened until after the main switch is thrown out, thereby insuring safety in case a short circuit on the line continues.

The McIntire Arc Lamp was conceded by many to be the star exhibit of the convention, the room where a full line was shown being a Mecca for central station men. An extremely handsome catalogue was distributed, and altogether the makers of this unique type of enclosed arc lamp, the International Arc Lamp Company, Houston and Mercer Streets, New York, and its general manager, Mr. G. R. McIntire, have every reason to be pleased with the effect produced at Niagara.

Mr. G. O. Rockwood had charge of the intrests of the Rockwood Manufacturing Company, of Indianapolis, Ind., and by means of a dynamometric model of his design, was enabled to clearly show the advantages of paper pulleys. The model, which in itself excited much interest from the neatness of its design, enabled the frictional resistance of a metal and paper pulley to be directly compared in terms of peripheral torque, the paper pulley registering a frictional adhesion several times greator than the former under the same conditions.

The Walker Company was on hand in force, the representation consisting of Messrs. H. McL. Harding, J. Holt Gates, W. A. Johnson, William Gibbs, A. F. Moore, H. D. Gay and A. V. Abbott. Delegates obtained from these gentlemen advance information on the features of the Walker alternating system, soon to be placed on the market, and had explained to them the merits of the new line of Walker arc lamps. The literature distributed by the Walker Company was above the convention average, its series of circulars taking the rank of technical monographs.

The Electric Arc Lamp Company was represented by Mr. Harry Astruck, general manager, whose geniality won many friends. The handsomest souvenir of the exhibition was presented to visitors to the "Pioneer" exhibit, consisting of a sterling silver match safe. Prof. L. B. Marks, electrical engineer of the company, was in attendance on the convention, and much regret was expressed that the "jamming" necessitated by the length of the programme did not permit time for a discussion to follow the reading of Prof. Thomson's paper on arc lamps, which would have enabled Prof. Marks to add largely to our knowledge of enclosed arcs.

The H. W. Johns Manufacturing Company was represented by Mr. W. F. D. Crane from its New York office. In an exhibit held in a corner of the hotel lobby were shown examples of its electrotherm electric heating pads, toggle-clamp feed wire insulator, "H. W. J." electric heaters, its new arc lamp hanger and numerous samples of vulcabeston and moulded mica insulating materials. The electrotherm created much interest on account of its comparative novelty and the satisfactory manner in which the small current utilized maintained the temperature of the pad indefinitely. Special attention was called to the method of regulation by means of a regulating socket and of the insertion in the pads of the thermostat, which prevents the temperature from exceeding the safety limit.

Mr. Jas. I. Ayer, was one of the prominent figures of the convention despite any desire he may have had to play a more minor part. As a former president and a member of several important committees he was continually consulted on the business of the association. If anyone asked who some one else was, the reply was apt to be, "Ask Ayer; he will know." As representative of the American Electric Heating Corporation, he was in constant demand to answer queries on electric heating, new heating apparatus, etc. One of the few real hits in the exhibit line at the convention was the new American rheostat, which is made of small units easily, rapidly and cheaply replaced in case of defect—the units being disks scarcely the size of a silver dollar and consisting merely of a resistance wire embedded in an insulating porcelain.

President H. A. Wagner and Messrs. Fredk. Schwedtmann, A. H. Mustard and John Mustard looked after the interests of the Wagner Electric Manufacturing Company, of St. Louis. In the exhibition quarters was shown in operation a Wagner single-phase, self-starting motor, which excited much interest. The motor is started with load as a commutated armature, motor and when in a few seconds synchronism is reached, the bars of the commutator are short-circuited by a sliding ring, thereafter the machine working as a simple induction motor. In another building the same company exhibited a new type of dead-beat indicating meter; a line of switches and the Wagner transformer. Visitors were presented with a souvenir in the form of a handsome button bearing a view of the Wagner works.

The Westinghouse Electric & Manufacturing Company had a large force in attendance, including Messrs. C. F. Scott, B. G. Lamme, E. H. Heinrichs, W. K. Dunlap, M. McLaren, C. A. Brogg, T. B. F. Payne, F. S. Smith, Maurice Coster, Paul T. Brady, T. C. Fenyear, F. N. Waterman, W. K. Archbold, H. P. Davis, Clarence A. Ross, R. S. Fecht, Arthur Hartwell, C. S. Skinner, C. F. Medbery. The exhibit, which was in charge of Messrs. Dunlap and McLaren, was an operative one, including a direct-current motor driving a 7½-HP direct-current generator and a 10-HP two-phase alternator, the latter furnishing current to a small induction motor. Other small motors and constant-potential lamps were run from the circuits. The compact and mechanical appearance of all the Westinghouse machinery was particularly notable. Other apparatus consisted of Shallenberger wattmeters on the various circuits, transformers of various sizes, panel switch-boards, lightning arresters, etc. Among the literature distributed was a handsome pamphlet giving views of Westinghouse machinery installed in the various plants at Niagara.

The General Electric exhibit, though smaller than that of some other years, was yet the most comprehensive at the convention. It comprised a display of long-burning arc lamps for both direct and alternating-current circuits, the latter a recent development of this company's. They also showed a number of focusing lamps for high-tension, series arc work, as well as long-burning arc lamps for use in series on 220 and 500 volts railway current. The transformer exhibit included a number of the recently developed type H transformer, and to make this exhibit more effective, all the different parts which make up the transformer were shown in detail, as well as the cores in the various stages of completion. In connection with this exhibit, a pamphlet was distributed, entitled "Use and Abuse of Transformers," perhaps, the most complete treatise on this subject ever issued in the form of commercial literature. There was also a working exhibit of the Wirt lightning arresters with samples of the latest types for both alternating and direct-current work. The meter and instrument exhibit comprised samples of the latest inclined coil instruments for switch-board and portable use and a series of Thomson recording wattmeters, including a "penny-in-the-slot meter," which attracted much attention. On the tables in the rooms were a number of fan motors both for alternating current and direct current. An X-ray set was installed at the headquarters and a continuous exhibition given under the charge of Messrs. F. M. Kimball and Caryl D. Haskins. The souvenir for this year was a small book descriptive of the Falls and of the large amount of work the General Electric Company has done in that vicinity. The representation of the General Electric Company included Third Vice-President E W. Rice, Prof. Elihu Thomson, Mr. C. P. Steinmetz, and Messrs. S. Dana Greene, M. K. Eyre, W. L. R. Emmett, A. R. Bush, Fred M. Kimball, John McGhie, J. R. Lovejoy, H. W. Hillman, H. C. Wirt, J. W. Kirkland, J. M. Andrews, A. D. Page, John W. Howell, Chas. B. Davis, C. D. Haskins, S. B. Paine, C. E. Esterbrook, H. J. Buddy, D.R. Bullen, John P. Judge, A.F.Giles, J. C. Calisch, Thomas H. Fearey, D. F. Potter, H. H. Crowell, W. F. Hayes, Edward K. Gillette, L. H. Cooper, T. W. Dixon, Irving Hale, F. M. Ray, W. D. A. Ryan, G. De B. Greene.

TELEPHONE CONVENTION NOTES.

The Stromberg-Carlson Telephone Company, of Chicago, exhibited an extensive line of telephone instruments and switchboards.

The Phoenix Interior Telephone Company, of New York, made no exhibit, but its interests were well looked after by Mr. John H. Scofield, its treasurer.

The National Carbon Company, of Cleveland, O., had on exhibition a very complete line of batteries, together with carbon specialties used in telephone work.

The Standard Underground Cable Company, of Pittsburgh, had its interests well looked after by Mr. F. S. Viele, manager of its conduit, construction and rubber sales departments.

The American Electric Telephone Company, of Chicago, made a large and complete exhibit of telephones, switchboards and all kinds of appliances used in a telephone exchange. The president of the company, Mr. P. S. Burns, was in attendance.

The Williams-Abbott Electric Company, of Cleveland, O., had on exhibition a line of samples of its high grade magneto bells for exchange and toll line service. The company was represented by president, Mr. S. D. Latty; treasurer, Mr. F. M. Kirk, and electrical engineer, Mr. J. A. Williams.

The Keystone Telephone Company, of Pittsburgh, Pa., exhibited nearly every grade of telephone used in exchanges; also an exchange switchboard, together with a full complement of desk sets. The company was represented by Mr. Burt Hubbell, secretary and treasurer, and Mr. J. G. Thursen, manager.

The Western Signal Company, of Chicago, had an interesting exhibit at the convention. The company was represented by Mr. B. F. Stewart who divided his time between showing the apparatus to visitors and securing several good-sized contracts. This company is working on a rather new idea in municipal signaling—that of subordinating the automatic apparatus now extensively used in fire and police signal work, to the telephone. On opening the door of their patrol box a signal is sent either to police or fire headquarters or both automatically. The telephone apparatus is then automatically thrown in circuit and the party can communicate with headquarters telephonically and give full particulars concerning the trouble. A unique portable telephone set was also shown for use on street railways. The entire outfit, including battery-transmitter and all other required parts, occupied the small space of 4 × 4 × 5 ins.

The Western Telephone Construction Company, of Chicago, had an exhibit which entirely filled one of the large parlors of the Cadillac Hotel and attracted much attention. The arrangement of apparatus was something of an innovation in exhibits of this kind and the effect was certainly pleasing. A large telephone booth with glass windows formed the center of the display board and was provided with two wings upon which the various smaller pieces of telephone apparatus were mounted. On the front of the booth and in its center was placed a complete 100-drop, metallic circuit switchboard, to the various drops of which were connected the different telephones mounted on the exhibit board, so that in fact a complete working exchange was practically illustrated. Visitors of the convention who were not familiar with the ordinary working of telephone exchanges, found much to interest and instruct them in this feature. Besides the apparatus on the exhibit board, two complete telephone desk sets were shown of extremely handsome design. The finest piece of apparatus in the whole exhibit, however, was the 200-drop table switch. board. This is a new design and embodies all the newest and best features of switchboard construction of this company. Noticeable among the latter were the new automatic circuit changers, which seem to be an entire novelty. All of the changes in the cord circuits made by this piece of apparatus were effected by a single lever, a slight pressure downward on which served to connect the operator's telephone across the cord circuit; a pull toward the operator connected the generator with the circuit of the called subscriber, while a similar one on the same lever disconnected the called subscriber from the circuit of the generator and connected thereto the circuit of the calling subscriber. One of the beauties of this arrangement is that at no time does either subscriber get a click in the ear when the other party is being called. The lever always returns to its normal position when released by the operator. All of the apparatus of this exhibit are samples of the regular line of goods put out by this company. The company was ably represented at the convention by Mr. James E. Keelyn, president, and Messrs. Kempster B. Miller, Jas. G. Nolen, Chas. P. Platt, J. A. Russel and W. D. Barnard.

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A MODERN CENTRAL STATION PLANT.

BY FREDERICK L. RAY.

IN MANY respects the new electric light station of the Citizens' Electric Light & Power Company, Terre Haute, Ind., is one of the most modern small plants in the country to-day. Equipped as it is with all the most improved appliances for the generation and distribution of electric current for all uses, it bids fair to serve as a model of its class for many years to come.

This station uses steam at a working pressure of 200 lbs. per square inch; vertical triple-expansion engines: direct-connected arc and two-phase generators; vertical water-tube boilers; fuel economizers; live steam purifiers; exhaust-steam heaters; mechanical stokers; exhaust-steam heating system; and every other appliance by which a saving can be effected. It is centrally located in all respects, and especially so in regard to the distribution of power and also of steam heating, being situated within two blocks of the post office and principal hotels.

The higher building shown in the rear of Fig. 2 contains the new plant, and is so arranged that it can be extended as the business increases. The illustration gives a front view of the new central station, and also of the electric railway power plant and car repair shops of the Terre Haute Electric Railway Company. The brick stack is for the street railway plant, while the iron one is for the lighting station. A plan view of the station is given in Fig. 3.

The engines are of the Willans central-valve, vertical, triple-expansion type, made by M. C. Bullock & Company, Chicago. They are direct-connected to Western Electric 100-light arc dynamos, and to Stanley-Kelly 240-KW, two-phase generators. There are six of these engines of 100 HP each, direct-connected to six 100-light arc dynamos; and two of 360 HP each, direct-connected to two 240-KW two-phase alternators. Each engine has a separator attached so that any water of condensation or priming may be arrested and trapped back to boiler.

The 100-HP engines are of the double upright Wilians pattern, having two independent sets of three cylinders each, with cranks set opposite each other. The cylinders are tandem and the steam exhausts from each through a hollow piston rod into the space below, which serves as a receiver for the following cylinder. Steam is supplied through a single steam chest set across the top of the high-pressure cylinders. Before entering the chest, the steam is throttled to the pressure required to maintain uniform speed, by a centrifugal governor on the end of the crank-shaft. The 360-HP engines are the same as above, except that they are of the triple upright pattern, having three independent sets of cylinders each, with cranks set at 120 degs.

Special mention may be made in this connection of the constant thrust upon all bear-

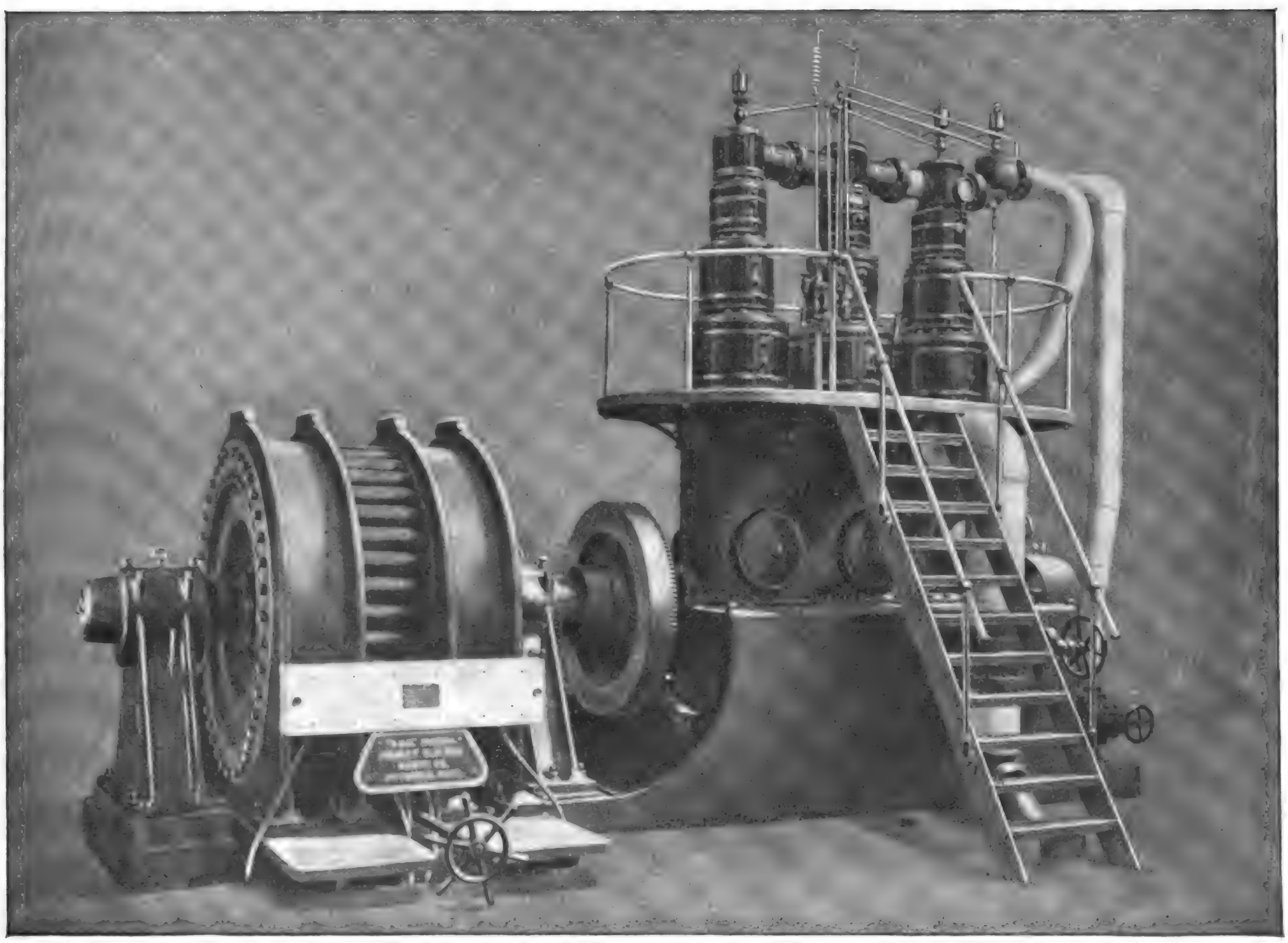

Fig. 1.—TWO-PHASE GENERATING UNIT.

ings and brasses, which is due to the steam acting upon one side of the piston only, thus enabling the moving parts to be kept always

FIG. 2.—VIEW OF CENTRAL STATION AND ELECTRIC RAILWAY BUILDINGS.

pressed against the crank-pins in the same direction. There is no hammering or back-lash, and the engines run at a high rotative speed with absolute silence. This is effected

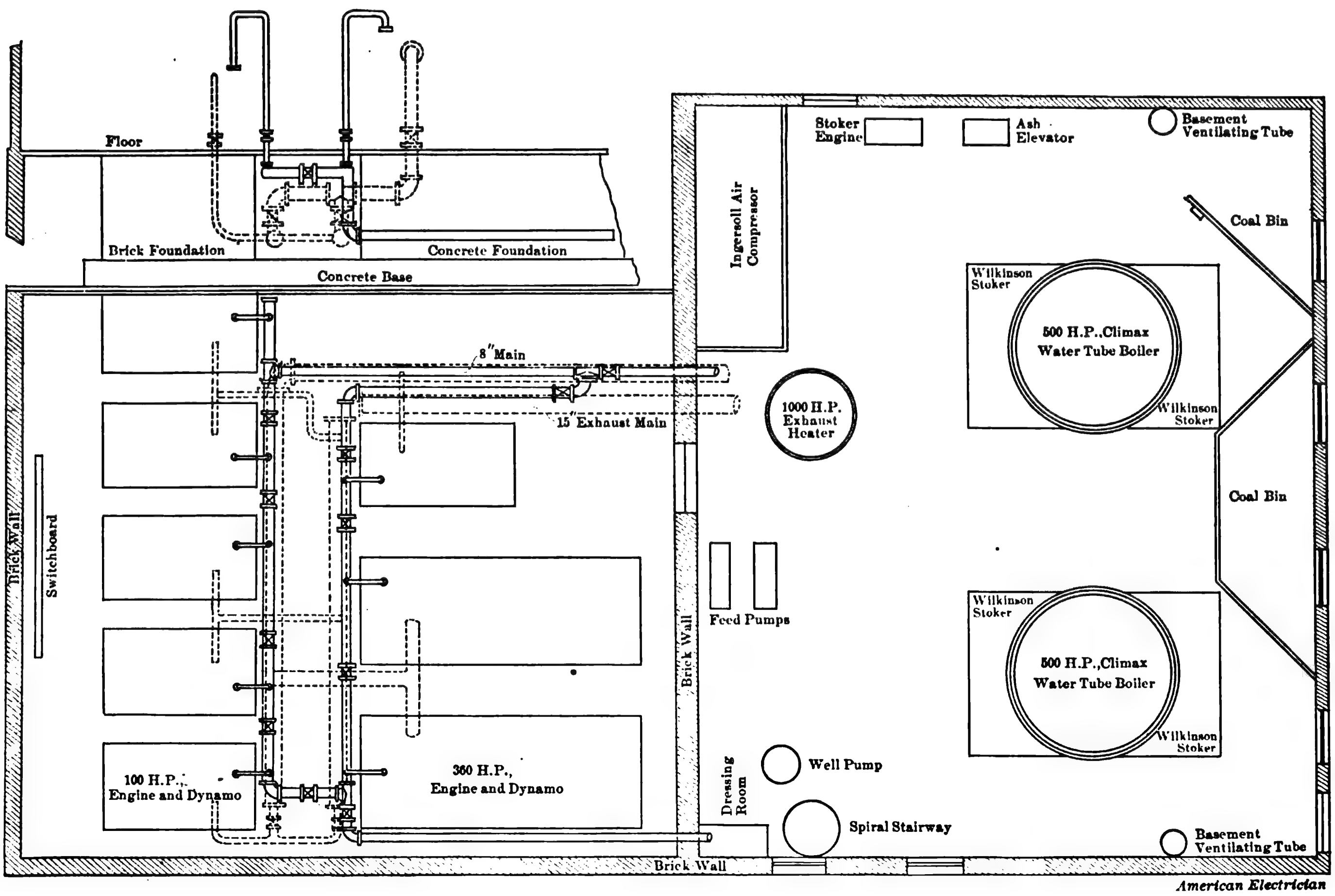

FIG. 3.—PLAN OF BOILER AND GENERATING ROOMS.

by air cushioning upon the out or non-effective stroke, which absorbs the momentum of the moving parts and ensures constant cushioning irrespective of compression in the steam cylinder.

Some of the engine foundations are made of hard brick laid in cement mortar, and others are of concrete. The concrete foundations were built up 12 ins. at a time, and each course allowed to dry three days before another course was put on. Before the engine foundations were built, a sub-foundation of 24 ins. of concrete was put in, which covered the floor space of the whole engine room. Upon this the engine foundations were built up and now securely stand. After the engine and dynamo were perfectly in line, the foundation bolts of the dynamo were sulphured in.

There is a basement 8 ft. deep below the engine room, which contains the steam and exhaust pipes and all other pipes and wires, which are so arranged that they can be readily manipulated; this does away with unsightly and troublesome fixtures above the floor, apt to be in the way of traveling cranes while handling machinery. The floor is of wood and iron, the structure being of cast-iron columns and I-beams set independent of the walls and foundation. On top of I-beams were fastened by bolts strips of wood as wide as the beam, and 1½ ins. thick. All bolt heads were let into the wood so that they cleared the top of the strips. To these strips is nailed a course of 1¾ × 6 in. pine, and on this is laid another course of right-angle matched quartered hard pine.

In driving nails, care was taken to avoid making contact with any part of the iron-work, so as to insure an electrically insulated floor. The result anticipated was attained, and the machine attendants are safe while at work at the machine; as an extra precaution, however, rubber mats are spread on the floor around the machines. The terminal posts and exposed parts of machines are covered with glass.

The roof of the engine room is made of iron and tile, with a large ventilator the full length of building, which has hinged windows that can be operated all together from the floor.

The arc dynamos, as stated before, are

direct-connected to the engines, and each dynamo is mounted upon a bed-plate common with its engine, but carefully insulated therefrom.

In coupling the dynamos to the engines flexible insulating couplings of special design are used. The interior bushings of these are embedded in cement, so that there are no exposed insulation surfaces on the interior, and the exterior insulation is formed of wood, the surface of which can be readily wiped clean while running; by this means a surface of at least 5 ins. in width is secured between the parts which are insulated from each other.

The dynamos are of the well known four-pole type (Fig. 5), manufactured by the Western Electric Company, having cylindrical magnet cores of wrought iron arranged horizontally, and terminating in salient poles with specially formed faces, which effect such a distribution of the field of force as to secure the production of a uniform current under all conditions of load. The armature is a four-pole, series-wound Gramme ring. The armature winding (Fig. 6) is the same as that of an ordinary Gramme ring, but the connections to the commutator are so arranged as to cause certain coils to operate in series with each other, and thus adapt the armature for operation in the four-pole field.

A special system of ventilation is provided in the armature. The driving spiders are cut away in places to admit air, which passes through spaces communicating with radial openings in the core, and thence through outer ventilating spaces between the coils to the air. The combination thus formed acts as a centrifugal blower to draw air through the armature core, and thus maintain it at a low temperature. After a run of twenty-four hours consecutively at full load, the rise in temperature should not exceed 50 degs. F.

The commutator connections are enclosed and cemented in a case or box, thus protecting them from mechanical injury aud preventing the formation of crosses between the wires. A feature of the construction is that the commutator and connection box may be easily and quickly removed, leaving the armature winding clear for inspection or repairs. In case of injury to coils on the armature, the injured coils can be disconnected and the machine operated even with a large number of its coils thrown out of action. The armature can be removed from the machine without dismounting or disconnecting the field-magnet frame in any way.

Automatic adjustment of the dynamos to different loads so as to maintain a practically constant strength of current at all times, is accomplished by a simple shifting of the collecting brushes backward as the load is increased or forward as it is decreased. This duty is performed by a simple form of regulator attached directly to the brush yoke, the regulator being mostly mechanical and not depending for its action on any sensitive devices placed at a distance from the machine.

Upon one side of the machine is a heavy slate base (Fig. 7), upon which are mounted the terminals from the armature field and line, each terminal being provided with a lock-nut for securing the wires and maintaining a perfect contact. Upon this base is also mounted the operating switch of the dynamo, which, when the machine is thrown out of operation, places the field coils, the armature and the line all on short-circuit. A magnetic blow-out lightning arrester is attached to the upper part of the slate base, thus guarding the dynamo from injury from that source.

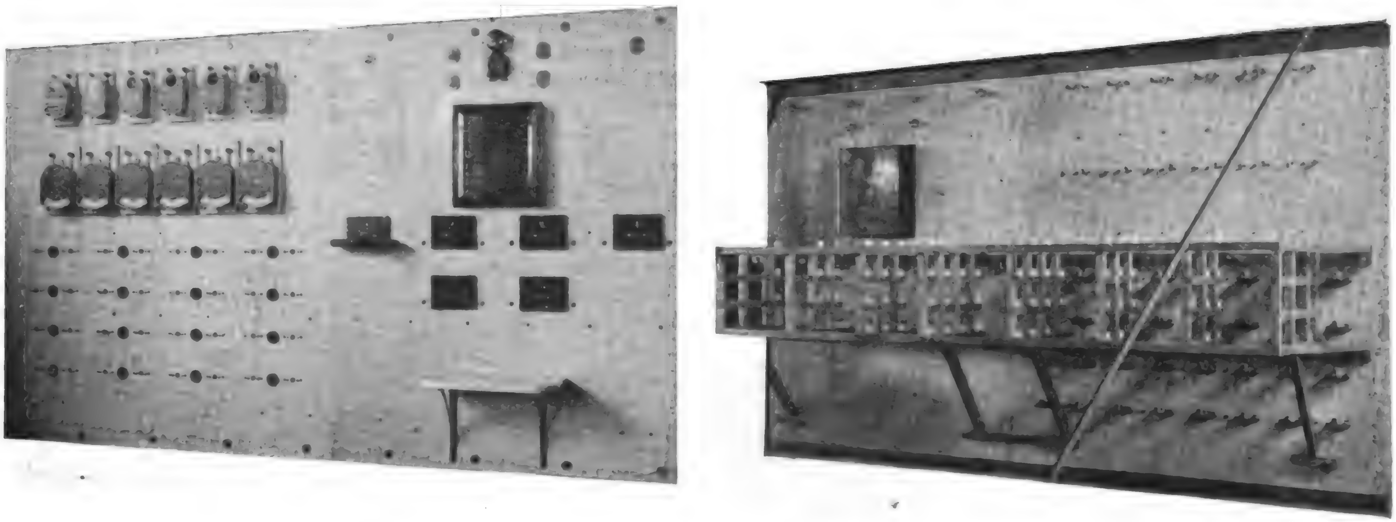

FIG. 4.—FRONT AND REAR VIEWS OF ARC SWITCH-BOARD.

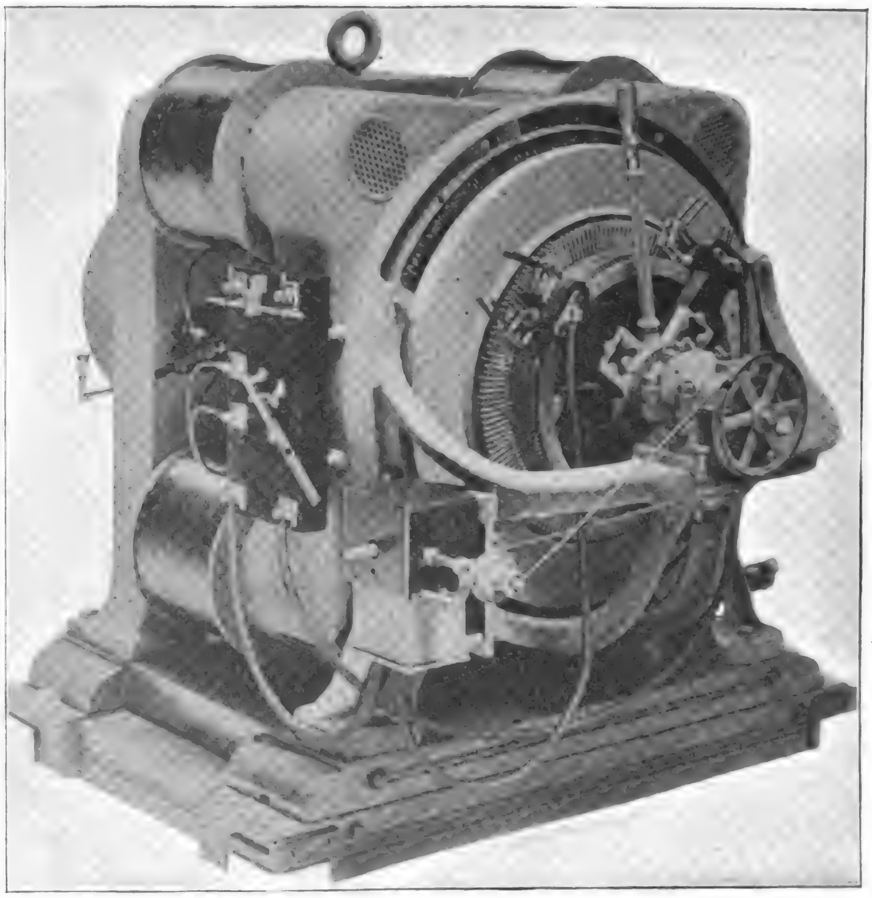

FIG. 5.—100-LIGHT ARC GENERATOR.

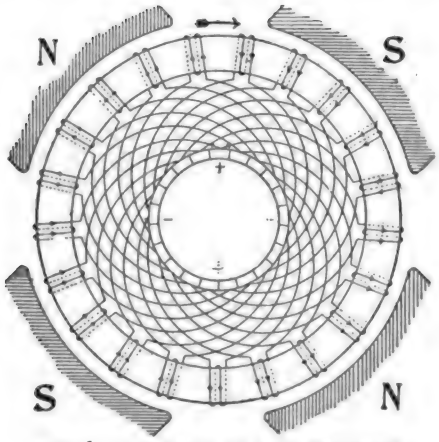

FIG. 6.—DIAGRAM OF ARC WINDING.

The switch-board for the arc-light circuits is of white marble and fitted with instruments furnished by the Western Electric Company. For each outgoing circuit there is an ammeter and a current direction indicator, which latter quickly tells whether the circuit has been "plugged" correctly or not. The arrangement of the switchboad is such that any one out-going circuit may be connected to any one of the dynamos, and two or more lines can be thrown in series on any one dynamo.

In connection with this switch-board is installed a bank of fifty 16-CP incandescent lamps for testing arc circuits while the load is on. These lamps are all connected in series, with a terminal between every fifth lamp to which connection is made. The bank has been a very effective device for locating grounds on lines. As an example of its use, if a test is made and twenty lights burn up to candle power, this would indicate that there is trouble twenty lights away from dynamo, less the equivalent resistance, in incandescent lamps, of the line. The arc lamps in use are the Western Electric Company's single-carbon type. Each city circuit has 100 lamps in series, giving a voltage of 5000.

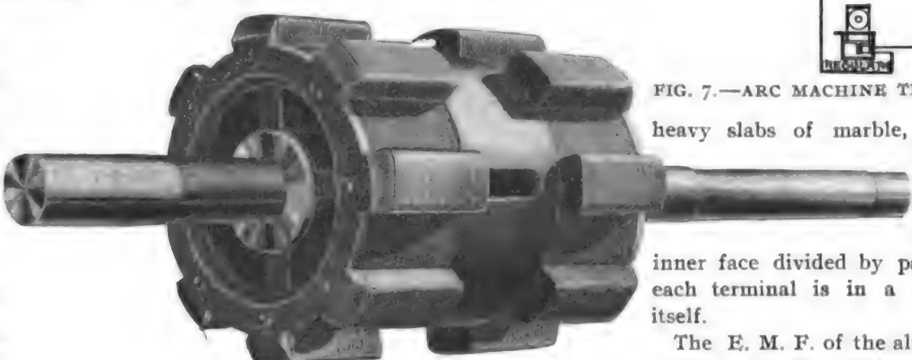
FIG. 8.—INDUCTOR.

The alternators are of the two-phase Stanley-Kelly inductor type, which is so well known as to require no extended description. In Fig. 1 an alternator is illustrated direct-connected to a Willans engine. Fig. 9 shows a machine with the armature or frame drawn apart, and a view of the inductor is given in Fig. 8. The armature coils are wound on the inward projections shown in Fig. 9, the windings of the two circuits of the generator being "staggered" with respect to each other, so that the two currents produced may differ in phase. The edges of the field spool are shown in Fig. 9; the field winding which, with its spool, is stationary, encircles the middle section of the inductor, but is entirely independent mechanically of it otherwise, the spool resting on the armature frame.

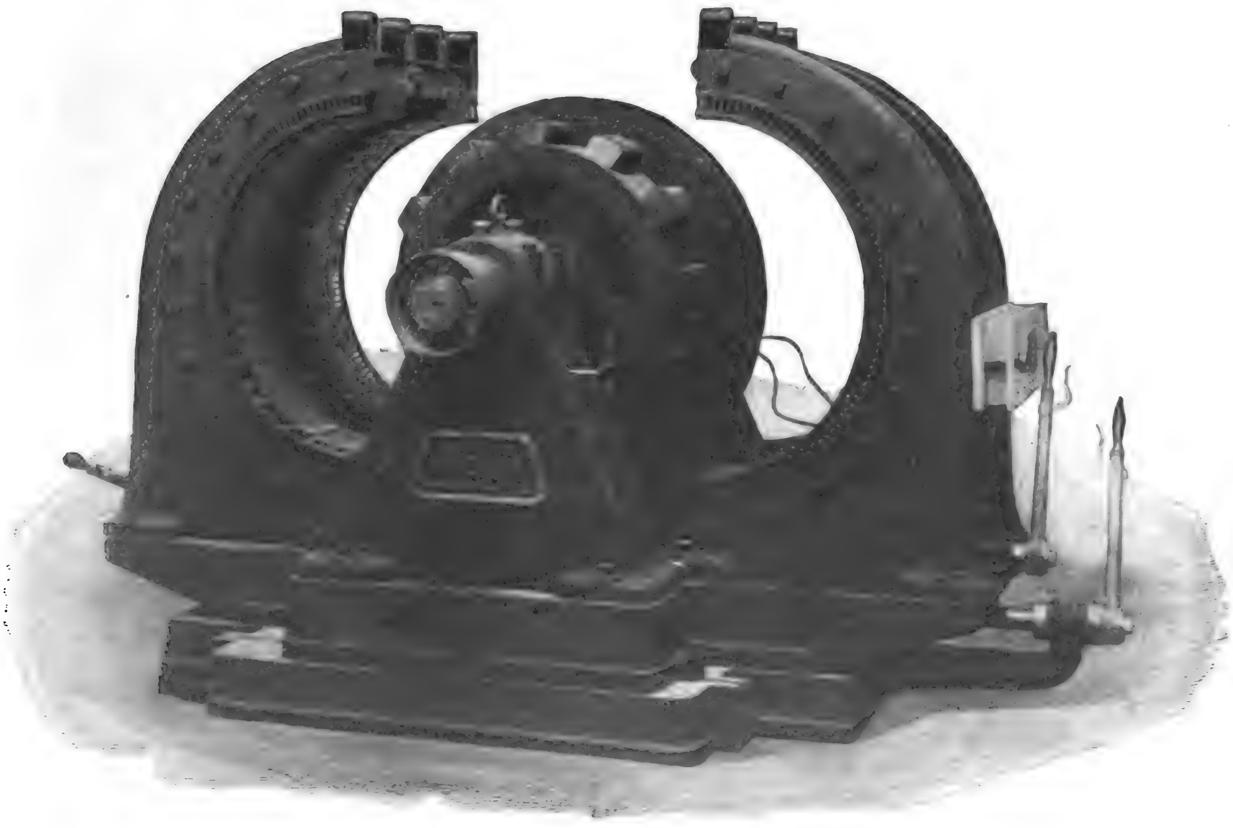
FIG. 9.—TWO-PHASE GENERATOR WITH ARMATURE DRAWN APART.

The armature and field wires are brought out from the machine to a terminal board, shown in Figs. 1 and 9, and from this the leads start. This board consists of two heavy slabs of marble, one secured to the machine and the other forming a removable cover, having its inner face divided by partitions so that each terminal is in a compartment by itself.

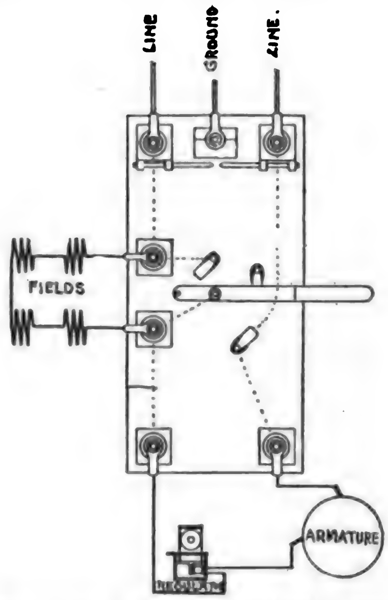

FIG. 7.—ARC MACHINE TERMINAL BOARD.

The E. M. F. of the alternators is 2000, which is transformed down to any E. M. F. desired, usually to 500 for motors, and 100 for incandescent lighting. The alternating-current switch-board is made of white marble and, together with its instruments, was furnished by the Stanley Company. Situated in another part of building from the main switch-board, is a feeder board from which the different circuits are run. In case of

trouble on the line at any place, the proper feeder is cut out and only that section wherein the trouble lies is without light.

For cleaning the dynamos a small Ingersoll air compressor is provided. Compressed air from this is also used for blowing dirt out of street car seats and for special work around boilers, such as heating the shell of a horizontal boiler to drive up the sag, and also to supply cool air to workmen while on a rush job of boiler work.

All transformers are carried on poles, except in the case of a very large installation, when they are placed on the inside, special care being taken in running the primary wires. Single-pole cut-outs are used in preference to double-pole cut-outs on account of the liability of the latter to cause trouble from short circuits. The motors employed are the Stanley two-phase type, the design of which is extremely neat and compact.

A diagram of the alternating-current load is given in Fig. 13, showing a winter and a summer load. The diagram is for a run of twenty-four hours, with a reading every thirty minutes. It will be noticed that there is considerable incandescent lighting in the early morning on the winter load which does not show up on the summer load. Also that the lighting comes on earlier by two hours in the winter than in summer, and runs considerably higher. The motor load is shown to be almost constant, while almost the entire lighting load comes on at one time—that is, for a few hours in the early part of the night.

The steam-generating part of the plant consists of two Climax water-tube boilers, shown in Figs. 10 and 11, each of 500-HP and made by the Clonbrock Steam Boiler Company. The steam pressure carried is something out of the usual order for stationary boilers, being 210 lbs., which pressure is apparently just as easily carried as 100 lbs. is in the ordinary boiler. The boilers are rapid steamers and readily respond to any changes in load.

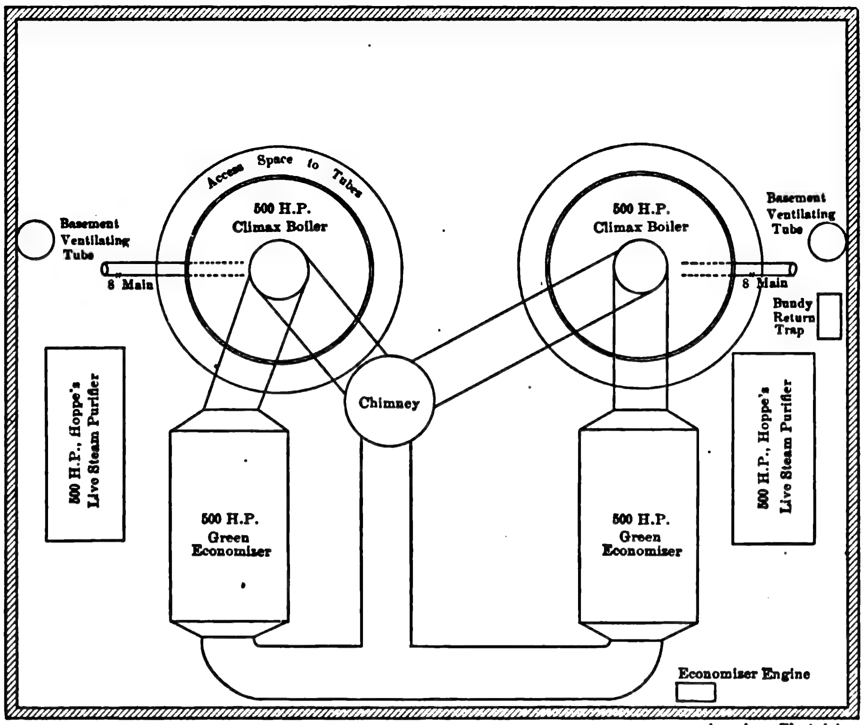

FIG. 10.—PLAN OF SECOND FLOOR OF BOILER ROOM.

The building that encloses boiler room is absolutely fire-proof. The walls are of brick, and the floors of cast-iron plate ½ in. thick bolted to I-beams supported by cast-iron columns. The roof is of iron and tile, and with the same arrangement for ventilation as is in the engine room. The roof ironwork was manufactured by the Wrought Iron Bridge Company, Canton, O. The boiler room was designed to have all coal and ashes elevated to the second floor, the coal to be delivered to the hoppers of the stokers, and ashes to a bin to be carted away. This device has not yet been put in.

Each boiler is equipped with two 250-HP Wilkinson automatic stokers. These stokers have hollow cast-iron grate bars into which a jet of steam is blown. The same grate bars are in these furnaces that were put in when the plant was installed, twenty-nine months ago, and they are in condition to burn many a ton of coal before they will have to be replaced. One particular feature of this furnace is its forced draft. When the boilers and stokers were first installed, it became necessary to light the city before the smoke-stack was erected. The boiler has a height of about 28 ft., and this coupled with a forced draft in the furnace, enabled the city to be lighted without any smoke-stack on boiler for three nights, a feat which could not have been accomplished with the ordinary boiler and furnace.

The chimney is of iron, and was made and erected in three pieces. It is 85 ft. long and 6 ft. in diameter, and rests on the second floor of the boiler room, which is 20 ft. high, making the total height of the chimney 105 ft. The raising of this chimney was quite a task, but it was successfully accomplished, without mishaps of any kind. Each section was 28 ft. long, and each weighed 3 tons. The first section was lowered into the basement of the boiler room; the second section was set on end by the side of the first section, when it was hoisted up and set on top of the first section. The third section was hoisted to the second floor, set on end, and then raised by a jack screw and set on top of the second section. Each section was securely bolted together, when the whole 85 ft. was raised from the basement to the second floor, a distance of 34 ft., with a jack-screw and cross-tie cribbing. The guy wires, eight in number, were all put on, and were let out by block and tackle as the raising progressed. This chimney gives a draft equivalent to about one-half inch of water.

The waste heat of gases of combustion is utilized to heat the feed-water. For this purpose each boiler is supplied with a Green fuel economizer, of 500-HP capacity, shown in plan in Fig. 10. Each economizer contains 160 pipes, aggregating 2000 sq. ft. of

FIG. 11.—BOILER ROOM, SHOWING STOKERS.

heating surface. The pipes are provided with scrapers operated by an automatic gear which is driven by a small Racine engine. The scrapers pass up and down over the exterior surface of the pipes, keeping the heating surface in a clean and effective state.

The feed-water enters the economizer

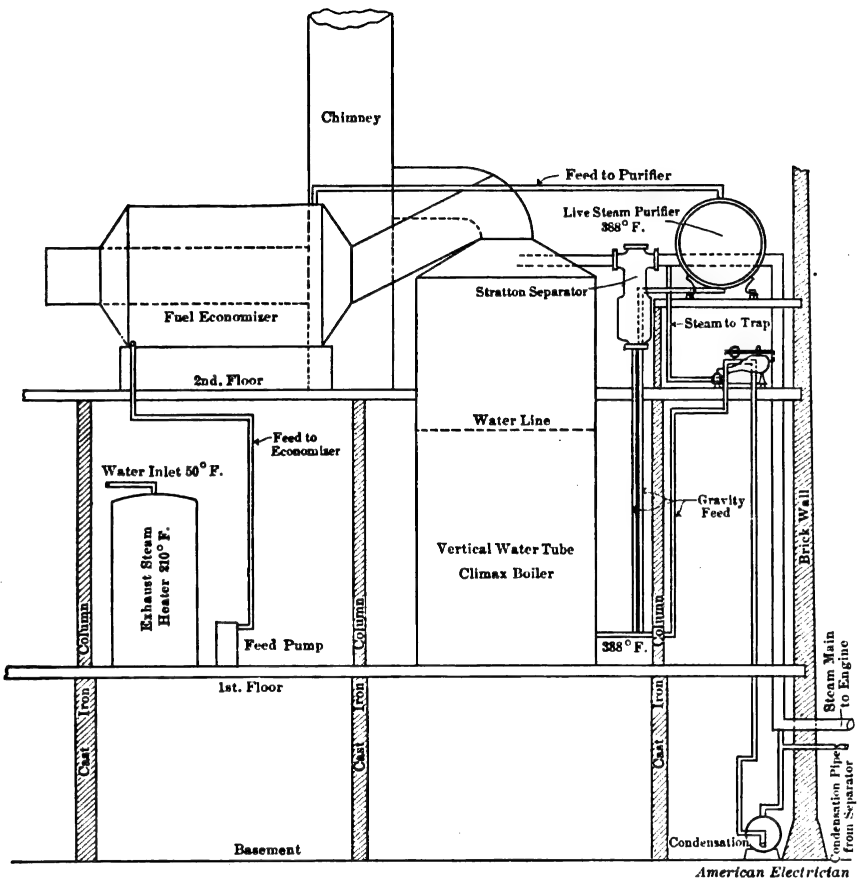

FIG. 12—ARRANGEMENT OF HEATERS, PURIFIERS AND SEPARATORS.

after passing through the exhaust heater, at a temperature of 200 degs. Passing through the heating pipe in an opposite direction to the current of gases of combustion, the temperature of feed is raised 100 degs. or to 300 degs. Thence it passes to a live-steam purifier.

The special feature of the economizer is that it is encased in sheet-iron instead of brick, as is the usual method. This sheet-iron is lined with terra-cotta lumber, 2 ins. thick, and is made in sections, flanged and bolted together, so that it can be readily taken down, at little expense, for repairs. The usual loss by radiation is materially reduced and infiltration of cold air through cracks in brickwork effectually prevented.

There are two Hoppes live-steam purifiers (Fig. 10), each of 500 HP, one for each boiler. They are set 8 ft. above the water lines of the boiler, so that there is no trouble about the discharge of water by the gravity pipe. The purifiers are so piped that either of them can be operated on either boiler. To provide a steam circulation the steam supply for the Wilkinson stoker is taken from the purifier, and answers the purpose exceedingly well; the stoker requires a constant supply, and, therefore, if the purifier should, from any cause, fill with water, it would be quickly noticed. To facilitate cleaning of the purifier, a large sheet-iron pan is erected on a level with the bottom of the purifier, which has a connection to a sewer.

For heating feed-water there is a 1000-HP Excelsior, exhaust-steam heater. All live-steam piping as well as all hot-water piping, the purifiers and separator, are covered with magnesia sectional covering. Before the pipes and purifier were covered considerable trouble was experienced from joints leaking, which entirely disappeared after the covering was put on.

The method of handling condensation from pipes and separator is illustrated in Fig. 12 All water of condensation from the separator on the engines and steam main is conveyed to a receiver in the basement of the boiler room, and from the receiver it is returned to a Bundy return trap, which rests on the second floor of the boiler room; from this trap it is returned to the boiler at a little less than boiler temperature. The trap rests 5 ft. above the water line of the boiler and easily discharges all water back to the boiler as it is condensed.

Each engine is equipped with a separator on an 8-in. main from the boiler, and each boiler has an 8-in. Stratton separator, the drain for which is connected to the bottom of the boiler so that all water of priming is automatically returned.

The water supply is derived from two 6-in. drill well pumps, 85 ft. deep, which give an abundant supply of water, the only drawback being that it is a little hard for use in boilers. Water connection is also made to the city water works, so that a reserve is always at hand. For boiler feed-pumps there are two $8 \times 5 \times 10$ Deane duplex pumps, with bronze valves, and bronze packing rings on the water pistons.

The present street lighting is on the all-night schedule, with a forfeit for every light not burning, which means that all lights burn as compared with the moonlight schedule with part pay when out, which was the plan of lighting the city formerly had.

In connection with this plant is operated an exhaust steam-heating system for heating residences and business houses. This was put in by the American District Steam Company, of Lockport, N. Y., and has proved a valuable addition to the lighting and street railway business of the company. Situated as the plant is, in the central part of the city, the supply of exhaust steam is rapidly being taken up for heating. By means of this auxiliary, the company is enabled to utilize a waste product at very little expense after the first investment for mains. The exhaust steam plant comprises about one-half mile of mains, and when extensions are made, as contemplated, so as to allow no exhaust steam to go to waste, it is believed that the income from the sale of exhaust steam for heating will go far towards paying all fuel bills at the station for the entire year. The rule seems to be that 100 HP of exhaust will heat 1,000,000 cu. ft. of space in the coldest weather. If, during certain hours of the day, the amount of exhaust steam should be insufficient, an automatic delivery of live steam from the boilers is provided, thus enabling the boilers and men to be kept busy during the entire time.

The officers of the company are: President, Mr. Russell B. Harrison, who has brought Terre Haute from "darkness into light." The general manager and treasurer is Mr. M. F. Burke, to whose indefatigable energy much of the success of the plant is due.

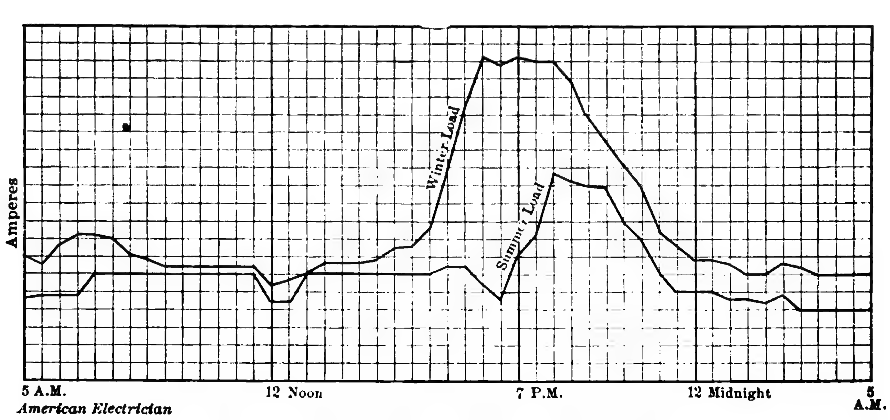

FIG. 13—SUMMER AND WINTER LOAD CURVES.

CIRCUIT BREAKERS A STEP BACKWARDS IN ELECTRICAL PROGRESS.

BY HARRY H. CUTLER.

A great deal of interest is being taken of late on the subject of the unreliability of fuses, and the advisability of more thoroughly protecting electrical circuits by means of circuit breakers. We have read many excellent articles in the leading electrical journals, showing the wide variations of current at which fuses blow, and giving elaborate tables and plotted curves.

The drift of most of this work, however, appears to be in the direction of attempting to prove that fuses are unreliable, rather than in searching for a way to make fuses reliable. Everybody knows who has given electrical matters any study at all, that electric lighting and electric transmission of power would have no commercial existence at the present time, if it had not been for the fuse. We might possibly get along without them now, with our present knowledge of electrical devices, but the developing of incandescent lighting in the early eighties could never have been accomplished without this same much-abused fuse.

I have heard people, supposed to be well posted in electrical matters, state that fuses are unreliable because they know of three instances where they had been taken out and copper wires substituted for them, even in one case to inserting a "rusty nail." Therefore, they agreed that as fuses were easily tampered with, they should be protected by circuit breakers. One would think from this, that a circuit breaker could not be tampered with.

I have also heard a great many people state that electricity is dangerous, and that quite a number of people have been killed by it; therefore, it follows from the above method of reasoning, that a man should always be careful to drop a nickel in the slot, and take out an accident policy, before entering a street car.

I have heard others give as a reason for preferring circuit breakers, that fuses do not act quick enough. It is for this reason that we see great long rows of circuit breakers on the switch-board of every railway power house, with a man chasing himself up and down, to throw them in every time they go off with a flash and a bang, like the discharge of fire-arms. This is all very nice for the manufacturer of circuit breakers, but very expensive and annoying for the railway companies and, in my opinion, entirely unnecessary, and a step backward in electrical progress.

A fuse properly constructed is the most reliable of anything on the market for opening a circuit under any and all conditions. A circuit breaker as usually constructed is, in nine cases out of ten, nothing but a nuisance because it operates nine times out of ten, when there is no real necessity for its doing so, and the tenth time, when it is actually necessary to open the circuit, a properly constructed fuse, would have answered just as well. I know that this is a very broad and sweeping statement, and will be promptly turned down by most engineers who read this article, as utterly absurd. The whole trouble with fuses, is that they are not made right. They are constructed in direct defiance to the very laws which cause them to act. In the early days, when I was running my first central station, in 1885, a fuse consisted of a round thread of lead, wrapped around a screw head, fastened to a wooden block. This same fuse is in extensive use to-day, and can be purchased in any size, at any supply store. I have a big one on my dynamo at my factory to-day. Many a time, in the early days, I have been rung up by 'phone in the middle of the night, and have gone down to some old saloon full of drunkards, crawled up on a step ladder, and tackled a rosette, arranged so that if I could walk on the ceiling like a fly, I could have more easily removed the fuse, burned out under the screw-head, and put in another.

I soon got sick of this sort of thing, and clamped all my fuses with pieces of sheet copper, and put the copper under the screw-head, and my troubles on this score ceased. Other people naturally enough, discovered the same remedy. Some one, I forget his name, patented it, and put the well known copper tip fuse on the market. This was a great step in advance. But here we have stopped.

Electric lighting then made enormous strides, and fuses of greater carrying capacity were required, so flat strips of lead were securely fastened to copper terminals, and screwed, or bolted to large blocks of copper or brass. This is the standard Edison fuse of to-day—a monument of monstrous stupidity, and a disgrace to the electrical profession.

Now let us consider what it is that causes a fuse to blow, and open the circuit. Is it not simply that the fuse offers a resistance to the passage of the current, gradually getting hotter and hotter, and finally getting so hot that it fuses, hence its name? Of course, fuses are frequently burned out by having a poor contact on the terminal, but this is remedied by the copper tip, as pointed out above. If there is any other cause of fuses blowing I do not know it, and should like to be informed.

I take the ground, then, that fuses blow because they get hot and melt, and that this is the reason why they blow at almost any amount of current they may feel like accommodating, at the time.

What causes anything to get hot? The source of heat is supplied faster than it can be dissipated. How is heat dissipated? Chiefly by radiation and conduction.

How can we increase the properties of a body to dissipate heat? In two principal ways: First, by increasing the radiating surface in proportion to the cross-section and second, by increasing the amount of heat-conducting, or heat-absorbing material in the immediate vicinity.

There used to be an old rule in practice among electricians that a copper bar having a cross-section of 1 sq. in., would carry 1000 amperes without heating, and larger bars in this proportion. This is mere nonsense, but still to be found in many recent books and engineering leaflets. All up-to-date central stations save copper by using laminated bus bars, each bar being wide and thin, thereby securing a large radiating surface. Three thousand amperes can easily be carried per square inch of cross-section in this way. Edward Weston uses the same principle in his shunt block for his switch-board instruments.

The much-abused fuse is also made thin and wide for large sizes, thereby dissipating the heat to the best advantage, to say nothing of the enormous heat-absorbing power of the massive blocks to which large sized fuses are connected. This is just what is not wanted. No wonder fuses are slow in blowing and unreliable, exposed to drafts of air, and their action retarded by the slowness with which large masses increase in temperature. In regard to this latter property, I spent a great deal of time and money some years ago, experimenting with hot wires. I constructed several large ammeters, based on the principle of the expansion of wires by the heating effect of the current passing through them. I built one ammeter reading to 500 amperes on this system. It took, I believe, about ¼ HP to operate it, and I abandoned the principle, for that reason.

Now, if the 500 amperes had been carried through one large ribbon, it would have taken at least three minutes to heat up and cause the needle to move over the scale to the 500-ampere mark. The instrument was constructed differently, however; it had a very fine wire, which carried a very small proportion of the current, and therefore got hot very quickly. The rest of the current was shunted around the fine wire. The result was an absolutely dead-beat instrument, with a rapidly moving needle. The Cardew voltmeter is another well known device, having an extremely fine wire which expands instantly the current passes through it.

With the above facts before us, can we not see how fuses should be constructed? If a quick and accurate blowing fuse is desired, it can be constructed as follows: First, so enclose it, as to protect it from drafts of air, thereby stopping the dissipation of heat through radiation and convection. Second, make the distance between the fuse proper, and its terminal block so great that little heat can be lost through conduction. Third, make the main fuse out of a number of small round fuses connected in multiple to the two terminal blocks. I will guarantee, to connect such a fuse in series with any circuit breaker ever yet put on the market, short-circuit 220, or 500 volts through these devices, and blow the fuse.

But do we want a fuse that will blow as quickly as this? In my opinion, no. It would be just as much of a nuisance as a circuit breaker is. A word as to why it is not advisable to open a circuit too quickly.

First, then, why do we want to open the circuit at all with overload devices? Because, if a large amount of current were allowed to flow, much damage would be done to the motors, generators, lines, etc. What would this damage consist of? The armatures of the motors would get hot, and burn out. Their commutators would be scarred. The lines, switches, etc., would get hot and fuse, if we did not protect them. The trouble then, is almost entirely caused by heat. Does anything get hot instantly? I think I have made it clear that it takes time to heat anything. Why, then, do we want to open a circuit instantly? There are other reasons which I will mention later.

Every electrical engineer knows that any good motor will stand a 100-per cent. overload for a few seconds without damaging it in the least. If this load continued for, say, a minute or two, the armature would probably burn out. A great many motors have to be started under full load, especially those operating street cars, elevators, hoists, long lines of shafting, etc. In all of these cases, the motor cannot be started except with a current which, if continued for a minute or two, would be liable to damage the motor. The fire departments of some of our large cities, are going so far as to compel the installing of circuit breakers on motors operating electric elevators, with these results:

The elevator as a rule cannot be started when loaded with passengers or freight, except by using much more current than is required after the motor attains full speed. If a motor is used of the proper size to operate the elevator at full load, it becomes overloaded at the start. This means that the circuit breaker has to be set so high that it becomes of no practical use whatever. If set for 50-per cent. overload it would not operate to protect the motor after it is running and warming up, and would therefore be of only imaginary protection.

If set below 50 per cent. overload it would be continually going off, while starting, stalling the elevator, and obliging the operator to crawl out of the car the best he could, and go down to the cellar, and throw in the circuit breaker. I have seen a great many circuit breakers on electric elevators, and have always noted one or the other of two things: First, the circuit breaker was set so high as to be of no protection whatever; or second, the motor was a great deal larger than there was any real necessity for. So that the starting load never exceeded the maximum continuous safe carrying capacity of the motor. In other words, the motor was installed to fit the circuit breaker. One prominent elevator company, that I know of, uses a 30-HP motor, to do 15-HP work, and goes about blowing that its starting current is less than its running current.

Now a fuse of large cross-section, protected from the air, is ideal for this class of work, because, first, it has a time limit, and second, it has no machinery to get out of order. Why then, do we use circuit breakers? I say, it is because we can buy no good fuses on the market. What's the matter with making some good fuses, built on correct principles? I saw some the other day, I don't own the patent. I wish I did. They are enclosed air-tight. They are accurate. They dont make any flash, or spark, or noise. You would'nt know the circuit had been opened, and have to test it to see if it really has. I saw several blow at 150 amperes and 3000 volts. You would never know anything had touched them. Figure out the horse power of these figures, and imagine how a circuit breaker would have to be built, and what it would do under these conditions. This same make of fuses was tested recently for the benefit of the electrical inspection department of one of our large cities. The chief of this department did not even take the trouble to be present while they were tested, but was present when a certain circuit breaker was tested, and has passed a rule obliging all motors to be installed with an approved circuit breaker, thereby compelling people to go to the expense of purchasing an instrument that in nine cases out of ten will prove nothing but a nuisance. Now I manufacture circuit breakers; I sell lots of them, and expect to continue to. My circuit breaker is as good as any circuit breaker on the market, better than a great many of them, but not as good as a good fuse.

A word more about using circuit breakers on the feeders of street railway lines. It is claimed that circuit breakers in these feeder circuits must act instantly. Otherwise there is a liability of diminishing the voltage on the other feeders or of throwing the main circuit breakers and thereby shutting down the whole plant. There is a great deal that could be said on this question, both for and against, but argument aside, if you must have the feeder circuit open quickly, why not use multiple fuses, contained in one cartridge, and have several extra cartridges ready to connect in with a plug or switch. I think personally, that every circuit breaker should have a time limit. I know of at least one other manufacturer of circuit breakers who agrees with me, but he is a thorough electrical engineer of wide experience. The other manufacturers of circuit breakers are sitting up nights, trying to design circuit breakers that will act quicker than the other fellows', and will probably promptly deny that a fuse can be made to act quicker than a circuit breaker, and will shed salt tears if they come out to Chicago, and bring one of their circuit breakers, with them, and hitch it up in series with a properly designed fuse, and see the fuse blow.

Manufacturers of circuit breakers need have no fears, however, that their business will suffer through this article. It takes time to blow the fuses we now have in common use, and it takes time, a very long time, for the public to find out what is good and what is bad. If some one should discover to-morrow, how to obtain power from the sun to run their machine while the sun shone, and store up enough power to keep going on cloudy days, people would keep right along buying steam engines for fifty years to come.

It will take the managers of steam railways ten years to wake up to a realization that they can operate their roads to better advantage by using electricity. It will take time to get good fuses on the market, and I hope some time in the near future, to have the pleasure of reading an article which will attempt to prove that a circuit breaker is more reliable than the properly constructed fuses to which I have referred.

High-Frequency Vacuum.

A find, which a reporter thinks is important to the electrical world, has been made in the West. The discovery consists of a "complete model of an electric lighting plant," made by an eccentric inventor named John Ingalls ten years ago. By means of the "plant" a light similar to that from an ordinary incandescent lamp is said to be obtained, without the use of a filament. The reporter explains that the new light is caused "by waves of electrical energy forced through a vacuum of high frequency."

THE SELECTION OF ALTERNATING-CURRENT APPARATUS FOR POWER TRANSMISSION.

MACHINE TYPES.

BY H. E. RAYMOND.

In selecting alternating-current generators and motors for power transmission, the relation of the line to the machinery should be carefully considered. On the length of line depends to a very great extent the voltage to be employed, and the type of machine is much influenced by this item alone. The country through which the line is carried, should also affect the selection of machines. If electrical resonance is likely to be present in any noticeable amount, it should also be carefully estimated and due consideration paid to its effects. If the country is wild and inaccessible, with considerable wood, the line is liable to mechanical damage and, following, electrical injury, such as grounding, short circuits, etc.; and, if the machinery is to run no risk from these troubles, it should be selected such that the current on short-circuit will not be extreme, as the fuses generally used in power-transmission work are of greater carrying capacity than true safety devices would warrant.

As the starting current for both synchronous and induction motors, is from one and one-half to three times the full load current, it will be seen that, if we are to start when we want to, fuses must be placed in circuit that are of great capacity as compared with the full-load current rating of machines. In the abstract, the idea of fuses on the magazine principle is good, but in practice it is often unsatisfactory. For, let us suppose, we have a machine that requires at starting 160 amperes, and is rated at 60 amperes, full load. The load to be carried is a varying one, and as we must make some compensation for the periods of light load we allow short overloads of 25 per cent. to 40 per cent. ordinarily. As fuses rated to carry 160 amperes are generally for short lengths, we use 180-ampere fuses and so arrange them that we can cut out half of each. This gives us 90 amperes for each wire, and as ordinarily the high loads are of very short duration, the fuse will stand as long as the conditions are normal. The loads run up, let us say, to 70 amperes for several minutes at a time and warm the fuse considerably. If our load is a railway one, a car may become derailed and the extra current required to get it on again, the way it is generally done, brings our load up to 85 amperes, and over a hot fuse. The fuses in our experience, rated at 90 amperes and used on high-tension work would not stand even this amount, but it will do for an example. The fuse blows, we shut down, and unless we keep a stock of assorted sizes on hand, we must put on our 180 amperes again, and run the risk of extra heavy currents that might start a joint or char the insulation in our armature before a fuse blows, or keep putting in the 90-ampere size.

The main objections to fuses on this work are the lack of adjustability and the time element which enters into every case. In our opinion the ideal way to arrange and protect a plant using high tension and over 40 to 50 amperes is to place in the main circuit, circuit breakers capable of carrying

and opening safely the necessary starting current, and in series with these, and short-circuited by a switch, circuit breakers set to carry the maximum safe current for practically non-inductive loads, such as the loads of ordinary operation while running, and over heavy synchronous-motor loads. In starting, the switch could short-circuit the branch breakers and the main ones do the work, while after the speed was up and the current normal for running, this switch could be opened and the current all passed through the smaller set. These could be so arranged as to be quickly adjustable, and in cases of emergency they could be held in, for their instantaneous action when released would allow ample margin of safety in case of extra heavy load, etc. Fuses in place of the main breakers would answer, of course, but it would be saving a dime to risk a dollar, for a fuse heavy enough to carry the starting current is very likely to carry full short-circuit current too long.

A well designed alternator will stand a large overload, especially if it is of short duration, as the limit is solely of the insulation being heat-proof and the joints being large and well soldered. There is a limit though, and after a machine has been running with fairly heavy loads and become well warmed up, an extra large demand for current might do serious damage before a fuse could blow. It is for this reason mainly that the circuit breaker is valuable, the action being instantaneous, regardless of heat and duration of load.

This sounds as though the loads were going to burn out the armature because of the fuse being so large, the fuse being large so as to carry the loads, but the action of fuses is so uncertain that ample margin must be allowed or they will be blowing at all times. For it is certainly true that a fuse rated at 90 amperes will often, if of considerable length, melt when carrying but 75 per cent. of this current if it is continued for any length of time, while it will as often carry 25 per cent. to 50 per cent. more current if it is sudden and of but momentary duration. It will, therefore, be seen that if we wish to carry anywhere near the rated current, we must use a large fuse and run the risk of damage during extra heavy loads of short duration. The circuit-breaker, on the other hand, is practically instantaneous, and may be set at exactly the point desired.

In regard to the machines to use, any fixed opinion is difficult to hold, for the improvements in the machines themselves, and in the best practice of operation, keep up such a pace that anyone who endeavors to hold to one idea for all cases is apt to fall far behind. In any article on such a subject as this, personality must necessarily play a prominent part, and the opinions advanced hold weight only according to the experience from which they are formed. In the statements regarding the selection of machines, there shall be given suggestions, and reasons for them, which the experience of a number of years in this work induces the writer to believe most apt to give satisfaction in general.

It is apparent, of course, that the nature of the service will determine very largely the entire general arrangement; the number and size of generators and their arrangement; the number, size and type of motors or lights; the necessary regulation of voltage and speed. Future requirements should also be given due consideration.

Let us treat solely of polyphase alternators, and in this branch alone we have to decide between tri-phase and di-phase, saw-tooth wave and sine-wave E. M. Fs., high voltage or low, stationary field, inductor and revolving-field type. For motors we may choose from the above and also from the synchronous or induction types, the question also arises, Shall we have one exciter for all our machines or individual exciters? Shall we hook direct to our wheels or engines, shall we belt direct from them, or belt from line shafting?

The individual requirements of each case must be considered before deciding, but in our opinion, belting alternating-current power generators from a line shaft is to be avoided. If the generators are but 60-KW each, drive each by itself. No matter what our load is to be normally, we want to be *able* to run the machines in parallel, and belting from a common source will not allow of this to any degree of satisfaction.

If the plant is to be of a size worth considering at all, couple directly to the driving machinery. Belts take up valuable room, stir up dust, are noisy, will slip at times and consume power. Moreover, the mechanical strain on a bearing, of a heavy belt is tremendous and increases with the mechanical input or output, as the case may be. In a direct-coupled machine the strain is one of torsion, and the friction is unaffected by the load, except, that perhaps the extra amount of magnetism in an armature carrying heavy load may tend to sufficiently lessen the weight on the bearings to make up for the greater weight of a direct-coupled unit. In order to test the capacity of a dynamo run direct-hooked or belted, we raised the armature current of a synchronous motor 45 per cent. by under-exciting the fields, and ran it a day. The heating effect of this would be practically what that increase of real load would cause, and while the core was somewhat hotter, the armature coils were the same temperature as normally. The motor would not carry an increase in mechanical load of 25 per cent., as the bearings heated too much on account of extra pull of the belt. If we drive direct-coupled generators, our station may be made so flexible as to surprise any one inexperienced in this line. Our principal gain, however, is in the facility for paralleling. If we can give our armatures a constant, even rotary speed capable of accurate regulation, we can run any number, size and almost any type of alternators in multiple with each other. Absolutely exact division of load can be obtained by simply regulating the speeds of the different prime movers and we need not worry over differences in the form of E. M. F. waves.

If our load is largely in lights, other systems than polyphase will probably prove more satisfactory. Tri-phase transmission with three wires will give the greatest copper economy, and bi-phase greater facilities for distribution. Lamps can and are run on tri-phase circuits, considerably overbalanced with perfect satisfaction. We are running now 175 KW in motor service and 75 KW in lamps on one tri-phase circuit and certainly have no cause to complain. All variation in voltage is due to speed change, and with half the lamps on one leg and none at all on the other the unbalancing effect on the voltage is only 2 per cent. Tri-phase means fewer wires, switches and brushes, and in high-tension work the fewer of these the better.

Choice of machine type is most important and probably the most difficult to make. From the point of voltage, insulation and safety, the inductor type is the ideal. This style allows of all high-tension portions being stationary and heavily insulated, but the question of regulation may enter here to such an extent as to counterbalance the insulation advantages. This question may, however, easily be settled by a test and probably by a few letters or a visit to plants using such machines. The revolving-field type is somewhat similar, but probably the regulation is not as close in this as in the other.

In power work, where the conditions are apt to be exacting and severe, a good heavy field current is certainly of obvious advantage, and fields with plenty of iron are what we want. This we are not apt to obtain in any machine with revolving field. If we are to carry the fluctuating loads of most power plants we will often find it necessary to raise our voltage more than usual by heavily exciting the generator fields, and in order to do this we must have not only sufficient exciter capacity, but also a field considerably below saturation. This may enforce a sacrifice of efficiency to a small extent, but in power work we must allow a margin for unusual demands. If an abnormal load comes upon our generator or a system the extra current is likely to cause more damage than a few hundred volts increase of pressure at the generator, and if circuit breakers are used, is likely to unnecessarily open them. Aside from this, a synchronous motor will lug very heavy loads if the voltage is held up, and a fair increase will often safely tide over a hard pull and certainly we wish to obtain as continuous operation as is possible.

THE DESIGN OF A RELIABLE FUSE.

BY J. E. WOODBRIDGE.

The apparatus almost universally used as a protective device and safety stop in electrical work—the fuse—is, strangely, the most unreliable and erratic device used in the industry. A large part of this unreliability can be accounted for and is partly remediable, and it is to be hoped that the fuse will not continue much longer to be a source of reproach and a cause for suspicion of all electrical work.

If the simpler causes of its vagaries were remedied, the fuse might become an instrument of considerable precision, for the following reason: its function is primarily to open the circuit by melting, when the current passing through it reaches a certain value. The heat generated in it is proportional to the square of the current passing through it, so that any percentage increase of the current causes at least double as great a percentage increase of the heat generated in the fuse.

Consider, for example, the watts spent in heating a one-hundredth ampere fuse with different currents, the resistance of the fuse

being assumed to be one one-thousandth of an ohm. It may be seen that the heating effect is increased from 8.1 watts to 10.0 watts by an increase of the current from 90 to 100 amperes. That is, there is a 23 per cent. increase of the heating effect with an 11 per cent. increase of the current. Since the temperature of the fuse rises almost in proportion with the heat generated in it, this feature tends to make fuses twice as sensitive and reliable as any instrument whose operation depends upon a property of the current proportional to its first power, as for example, the magnetic cut-out.

The chief causes of the unreliability of the fuse are as follows:

The variation in the methods of rating used by different manufacturers; the variation of length required for different fuse-blocks, the cooling effect of the terminals materially increasing the capacity of the shorter fuses; the variation in the placing of the fuse in the block, those which touch the porcelain having far greater cooling powers and consequently greater capacity than those which run in air; variations in ventilation, a covered panel with its enclosed air often rising to 150 or 200 degs. F. when loaded, thus diminishing the capacity of the fuses therein; the immediate previous history of the fuse itself, since a fuse which has been carrying all it can stand for a considerable time, its block and itself being thoroughly warmed up, melts more readily than a cold fuse exposed to a sudden heavy load or short-circuit.

The obvious remedy for the first two causes of unreliability is the enforcement (preferably by the insurance interests) of specifications regulating the testing and rating of fuses and fuse-wire, and the construction of fuse-blocks. The specification of a block so cut away that the fuse could not conveniently be laid in contact with the porcelain would remedy the third difficulty. The requirement of thorough ventilation in all fuse-blocks and panels would remedy the fourth.

The design of a fuse that will blow with the same current whether the latter is applied abruptly or gradually is a more difficult problem. The cause of the difficulty is the heat absorbed in raising the temperature of the fuse, its terminals, and the material in immediate contact therewith.

When current is started through a fuse part of the heat generated is dissipated in direct air convection from the fuse itself, the remainder being spent in raising the temperature of the fuse, terminals and so forth. If a heavy current is applied for some time, these parts become heated up and absorb less and less of the heat generated in the fuse, requiring the latter to rise to a higher temperature in order to throw off this unused heat to the air. The fuse finally melts with a current considerably below that with which it would have melted when everything was cold. Obviously, if the cooling effect of the terminals and block, or rather the ratio of such cooling effect to that of the air on the surface of the fuse itself can be reduced, this discrepancy will be diminished.

This ratio can be reduced in the following ways:

By making the fuse links longer from terminal to terminal, thereby removing the middle of the fuse further from the terminals; by substituting a number of small conductors for the single large conductor of a fuse, or thinning the latter out into a sheet form, thereby increasing the direct air dissipation from the surface of the fuse itself; by lightening up the metal used in the terminals as far as possible, without diminishing the surface of the same; by providing for good ventilation by arranging the fuse-links in a horizontal position, with no obstruction to the free circulation of air vertically across the fuse, and possibly placing the fuses in a continuous draught, as in a flue opening; by blackening the fuse to increase its radiation.

Fuses are intended as a rule for one of two distinct purposes. The first is the protection of all conductors supplied through them against a current sufficient to cause unsafe heating. The second purpose is the protection of dynamos, etc., from undue strains and jerks arising from abnormal rushes of current.

In the use of the fuse for the first purpose, it is not, as a rule, essential that the fuse shall act with any remarkable promptness. No matter how great the rush of current, a certain time interval is necessary before the conductors to be protected can become unsafely hot. It is only necessary for perfect protection that the fuse shall heat up to the melting point before this takes place.

When fuses are used for machine protection, however, the fuse should act as nearly instantaneously as possible. In the cases, for example, of a short-circuit on a dynamo, or the sudden closing of a motor armature circuit, the current flows almost instantaneously; and the mechanical strains caused thereby, often enormously greater than the machine was designed for, are set up simultaneously with the currents. In this case the brief delay due to the time necessary to heat a fuse to the melting point becomes a serious factor.

This sluggishness of fuses due to the time required for melting them can only be reduced by reducing the ratio of the quantity of heat absorbed by the material of the fuse, in raising it to the melting point and melting it, to the rate of heat dissipation of the surface of the fuse when at the fusing temperature. One method of reducing this ratio is, obviously, by increasing the rate of heat dissipation or distribution to the air, from the surface of the fuse. This is the same treatment that was recommended above for remedying the inconstancy of fuses, and as stated there, may be accomplished by flattening the fuse, arranging the flat sides in a vertical plane open above and below, supplying good ventilation and so forth.

The other factor on which the sluggishness depends—the specific and latent heat of the fuse—can only be varied by changing the material of which the fuse is made. The theoretical determination of the metal or alloy best suited for fuses is given in the accompanying note.*

As the disturbing factor of end cooling is too irregular to be susceptible of mathematical analysis, without special experimenting, its influence has been necessarily neglected in this derivation. However, it is unlikely that end cooling would cause much delay on short-circuit working (for which this formula is particularly applicable) on account of the time necessary for the conduction of heat to the terminals. At any rate, for railway and other high-voltage service, the fuses may be made long enough, without undue loss of energy, to eliminate the effects of end cooling at their centers.

Inspection of the formula shows that the use of alloys to increase the resistance and reduce the fusing point of the fuse is wrong; and the effect is to increase the sluggishness of blowing, since the temperature enters into the denominator and the resistance into the numerator of the formula expressing that quantity.

On account of the lack of published data on the latent heat of fusion of metals, the writer has not been able to find which metal gives the lowest value for this expression of the promptness of melting; but the indication is that copper would be found to do so, because of its low specific resistance and high fusing temperature.

A series of experiments on this point would be more valuable than theorizing. Such experiments with short circuits could be readily made with a ballistic galvanometer, and their results would certainly be interesting.

The use of copper for fuses would have many advantages. All that would be necessary to determine the proper size of fuse wire for any case would be a wire gauge. If found desirable a constant difference on the B. & S. gauge could be adopted between the size of the wire used as a fuse and the leads fed through that fuse. For example, if the gauge difference were made twelve numbers, a fuse block, supplying No. 4 leads, would be fused with a No. 16 wire; No. 12 leads would require a No. 24 fuse, No. 16 cord would require a No. 28 fuse, and so forth. The practice of fusing up would thus be on a more uniform basis than it is at present.

Copper fuses are cheaper than lead, make better contacts with their terminals, absorb less power, and do not discolor the porcelain and burn the fuse-blocks as do the others. They are also less affected by temperature changes of the atmosphere than are fuses with a lower melting point.

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*Let $S\,R$ represent the specific resistance of any metal or alloy; $S\,H$ its specific heat per unit volume; $L\,H$ its latent heat per unit volume; T the rise in temperature above that of the atmosphere required to melt the same; D any cross-sectional linear dimension of the fuse, assuming the latter to be of the same cross-sectional form with each metal.

Then the heat absorbed in melting the fuse would be proportional to the specific heat times the rise in temperature plus the latent heat, all multiplied by the cross-section of the fuse; that is proportional to

$$(S\,H \cdot T + L\,H)\,D^2$$

And the heat-dissipating power of the surface is proportional to the product of the surface and the rise in temperature, or to $D \times T$. The ratio, which should be reduced to a minimum, is

$$(S\,H \times T + L\,H)\,\frac{D}{T}$$

But for any number of fuses of the same capacity of different metals, $\frac{S\,R}{D^2}$ is proportional to $D \times 7$, since the first expression is proportional to the heat generated, and the second to the heat dissipated, which two quantities are equal. Therefore D is proportional to $\sqrt[3]{\frac{S\,R}{T}}$. Substituting this proportionality for D in our previous expression, we have

$$\left(S\,H + \frac{L\,H}{T}\right)\sqrt[3]{\frac{S\,R}{T}}$$

as the quantity to be rendered a minimum.

WESTON VOLTMETER RESISTANCE CURVES.

BY "PRACTICAL."

The general tendency of the day is to reduce to a practical basis the more common electrical tests and thus to place in the hands of the electrical artisan a ready and reliable means of testing his work in its successive stages of completion.

In electrical manufacturing industries, no test is so often in demand as that of insulation, and for carrying out this test, no instrument is more popular and gives more satisfaction than the Weston voltmeter. These meters are made to meet all requirements of actual practice, and consequently are made for different voltages and of quite different resistances. A high voltage requires that the instrument be of high resistance in order that it may take a very small current and thereby absorb a minimum amount of energy from the system, but a lower voltage will admit of the meter's resistance being much lower and without absorbing any more energy from the system than does the high-resistance instrument on the higher voltage circuit. For example, suppose a 500 voltmeter to have a resistance of 100,000 ohms. At 500 volts, it will take a current of $\frac{500}{100,000} = \frac{100}{20,000} = \frac{1}{200} = .005$ ampere and will absorb an amount of energy $= E \times C = 500 \times .005 = 2.5$ watts.

If we now take the case of a 100 voltmeter having a resistance of 4000 ohms, it will, at 100 volts, take a current of $\frac{100}{4000} = \frac{1}{40} = .025$ amperes and will absorb from the system an amount of energy equal to $E \times C = 100 \times .025 = 2\frac{1}{2}$ watts as before. Thus we see the latter's resistance is only 40 per cent. of the former, but the loss of energy is the same.

The most popular test with the voltmeter consists in putting the instrument in series with the source of E. M. F. and with the insulation to be tested as shown in Fig. 1, and noting the deflection when the test lines are held together and also when held across the insulation to be tested.

If the deflection is the same when the insulation is in circuit as when it is not, it

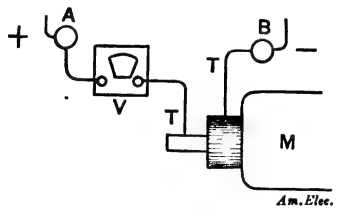

FIG. 1.—CONNECTIONS FOR TEST.

shows that the insulation resistance is zero, or, in other words, that some defect short-circuits it, because any E. M. F. applied to resistances in series will distribute itself among them according to their respective resistance values, the greater resistance having the greater drop of potential take place across it. In the present case there are but two resistances in series—that of the meter and that of the insulation under test.

If the meter resistance is 10,000 ohms and the deflection is halved upon introducing M into circuit, it shows that one-half the drop is taking place through M, and that the insulation resistance, therefore, equals that of the meter which, in this case, is 10,000 ohms.

If, upon introducing M, the deflection is not changed, it shows that M has no sensible resistance, for otherwise there would be some drop across it, and this would lessen the drop across the meter if the line voltage has remained the same.

If, upon introducing M into circuit, the deflection falls to zero, it proves the insulation to be so good that the voltage in use is unable to send through it enough current to sensibly affect the meter; in other words, the insulation resistance is infinite compared to that of the meter, and, therefore, absorbs the entire drop, leaving none for the meter.

The conclusion must not, however, be drawn that a zero deflection from 100 volts or less would indicate a perfect insulation, for with 500 volts or 1000 volts or more, a sensible deflection would probably obtain.

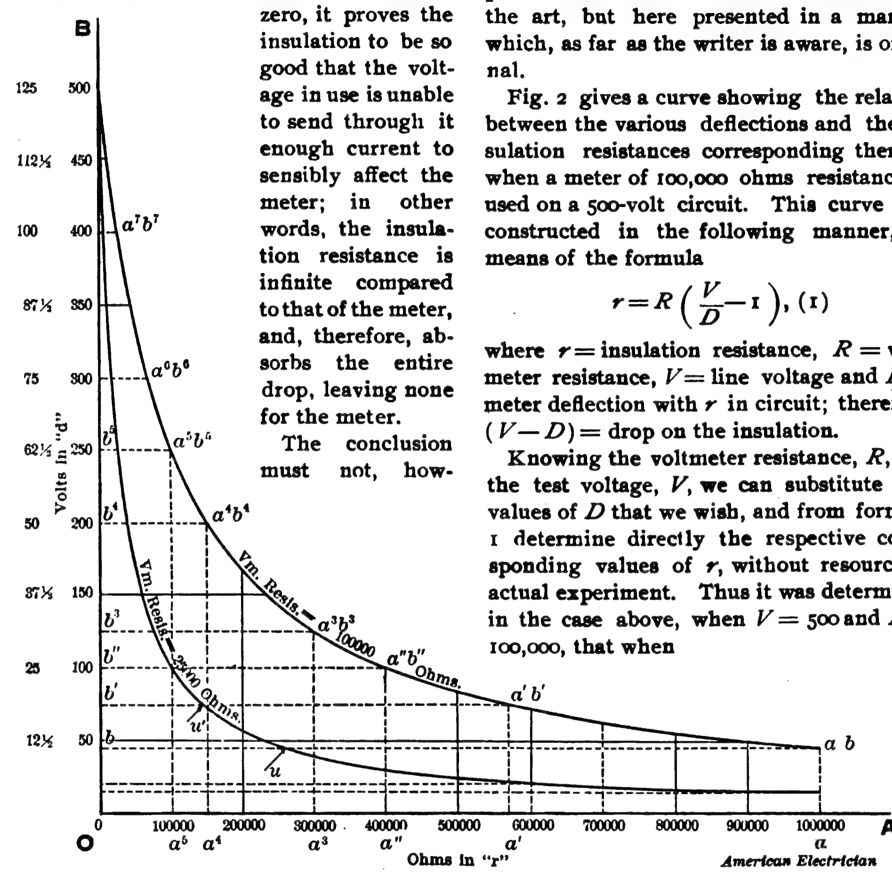

FIG. 2.—VOLTMETER RESISTANCE CURVE.

In the first place, no insulation is perfect or of infinite resistance; although it may be very high, it nevertheless has a definite value which can be determined and expressed in ohms, if the proper means are taken for doing so. Since this insulation resistance has a definite value, any definite E. M. F. can send a very small current through it, although this current may be too small to affect the needle of even a sensitive galvanometer. The E. M. F. could, however, be increased until an indication obtained. In the second place, a high voltage is apt to give a lower value for the insulation, not only because it can send a larger current through the definite resistance, but because it possesses more breaking-down power than the lower voltage and can therefore create faults in weak places that a low voltage could not develop.

It can then be derived from the above conclusion that the *value* of the insulation resistance corresponding to any given deflection, depends actually upon the voltage in use. This voltage should always at least equal that to which the insulation is to be continually subjected under working conditions. As working conditions vary, so will the test voltage required, and each shop, factory or station would enjoy an advantage in having some means of reading at a glance the insulation resistance corresponding to any given deflection on its particular meter, whatever might be its resistance and whatever might be the test voltage in use, and it is the object of this paper to propose and explain a method well known in substance to the art, but here presented in a manner which, as far as the writer is aware, is original.

Fig. 2 gives a curve showing the relation between the various deflections and the insulation resistances corresponding thereto, when a meter of 100,000 ohms resistance is used on a 500-volt circuit. This curve was constructed in the following manner, by means of the formula

$$r = R\left(\frac{V}{D} - 1\right), \quad (1)$$

where $r =$ insulation resistance, $R =$ voltmeter resistance, $V =$ line voltage and $D =$ meter deflection with r in circuit; therefore $(V - D) =$ drop on the insulation.

Knowing the voltmeter resistance, R, and the test voltage, V, we can substitute any values of D that we wish, and from formula 1 determine directly the respective corresponding values of r, without resource to actual experiment. Thus it was determined in the case above, when $V = 500$ and $R = 100,000$, that when

$D = 45, r = 1,000,000$	$D = 200, r = 150,000$
$D = 75, r = 570,000$	$D = 250, r = 100,000$
$D = 100, r = 400,000$	$D = 300, r = 67,000$
$D = 125, r = 300,000$	$D = 400, r = 25,000$
$D = 500, r = 0.$	

With these readings, the curve was then plotted in the following manner: Taking a piece of cross-section paper and selecting a point toward the lower left-hand corner, we draw from this point, called the origin, two lines, OA, OB, at right angles to each other. On OA we lay out the values of r, and on OB, the corresponding values of D. Since the edge of each large square on the paper contains the edge of ten small ones, ten of the large squares on OB will be a convenient distance to represent the maximum value of $D = 500$, for then the edge of each large square will represent 50 volts, and the edge of each small one, 5 volts.

1,000,000 ohms or 1 megohm is the standard insulation, hot, required of apparatus to be continuously subjected to not over 500 volts and we have taken 1,000,000, corresponding here to a deflection of about 45, as the maximum unit of our insulation scale. Taking ten large squares to represent this limit of 1,000,000 ohms each large square will represent 100,000 ohms and each small square 10,000 ohms. Now to plot the curve:

1,000,000 ohms corresponds to a value of $D=45$. Laying off 1,000,000 ohms on OA, we get point a: laying off 45 volts on OB, we get point b. Through a, draw a line parallel to OB, and through b, draw a line parallel to OA. The intersection of these two lines fixes one point, $a\ b$, of the curve. Again, laying off $r=570,000$ ohms gives point a'; and laying off $D=75$ volts gives point b'. Proceeding as before we get point $a'\ b'$, a second point on the curve. In a like manner we obtain points $a^2 b^2$, $a^3 b^3$ . . . etc., $a^6 b^6$, and the more points determined, the more restricted is the path of the curve, and the less liable are we to deviate from the true path when drawing it. Having fixed several points on the curve, we draw the curve through these points and we have the law of the curve whereby we are enabled to find out what value of r corresponds to a value of D, which we have not determined. Suppose we wish to know what value of r corresponds to a deflection of 350. Going up line OB, until we get to 350, we move across parallel to OA until we touch the curve, and then drop parallel to OB till we strike OA, where we find r to be about 42,000 ohms. This is near enough, actual figures giving 42,857.

This value of voltmeter resistance, 100,000 ohms, and of line voltage, 500, have been selected because the maximum resistance of most voltmeters does not exceed this and their maximum readings are generally some multiple or divisor of 500, *i. e.*, such voltmeters as are used for testing insulation. Using these round numbers makes it possible for any station engineer to derive simply the curve corresponding to his own voltmeter, whatever may be its resistance and whatever may be the line voltage available for taseting.

Suppose one has a meter of 25,000 ohms resistance to be used in testing from a line voltage of 125. How could we derive the proper curve from that of Fig. 2? 25,000 ohms is one-quarter of 100,000 ohms. Select any point as, b, on line OB, and move towards the curve and parallel to OA, one-quarter of the distance from b to ab. This gives us point u. Again, from point b', move out one-quarter of the distance to $a'\ b'$, this gives point u'. In a like manner quarter the horizontal distance from each of the points on OB, to its corresponding point on the curve and we get points $u^2 u^3$, etc. Through these points pass a curve. This curve will give the insulation resistance corresponding to any given deflection on a voltmeter of 25,000 ohms resistance used on a line voltage of 500. To render the curve applicable for use on a 125-volt circuit, it is only necessary to substitute for the maximum 500 in Fig. 2, the maximum 125 and divide the line, OB, accordingly as shown in the figure.

Let us check this up by means of formula (1).

$$r=R\left(\frac{V}{D}-1\right)$$

Here $R=25,000$ ohms and $V=125$ volts; suppose $D=25$ volts.

Then $r=25,000\left(\frac{125}{25}-1\right)=25,000\times 4$ $=100,000$ ohms.

Consulting Fig. 3 and running up OB, to 25 on the new or left-hand scale, we find the cross section line passing through 25, intersects the new curve on the vertical cross section line which passes through the 100,000 ohm point on line OA.

In the manner above, any curve can be derived from the standard given in Fig. 2. Take any point on the standard curve, divide its distance from OB into as many parts as the new voltmeter resistance is contained times in 100,000, take the length of one of these parts as the distance from OB of a point on the curve desired. Do this for as many points as is desirable—the more the better—and pass a curve through the points thus gotten. Then substitute for 500, the test voltage to be used in the case in hand, and divide OB accordingly. If it should so happen that a 125-volt meter must be used with a multiplier on a 500-volt circuit, the resistance of the multiplier must be included in the value of R. Thus, if the voltmeter measures 10,000 ohms and the multiplier 50,000 ohms, the value of R is 60,000 ohms.

THERMO-ELECTRIC BATTERIES.

To the Editor of American Electrician:

Referring to Mr. C. J. Reed's article on thermo-electric batteries in your issue for July, I noticed two or three assertions which are certainly erroneous and which perhaps may account for Mr. Reed's very strange assumptions in relation to the Jacques cell. He says, "I have shown elsewhere that in the Jacques cell the oxidation of the carbon to CO_2 could not evolve energy enough to reduce any substance in the cell, which would be necessary if the fused alkali is an electrolyte." But no substance is "reduced" and no energy is required for that purpose. The cell at the beginning contains carbon and the fused alkali. The carbon is oxidized and the alkali is changed to carbonate. Both operations *evolve* energy. Even assuming that the alkali is reduced, the metal would appear at the iron plate, where it would be immediately reoxidized by the incoming oxygen just as the hydrogen is oxidized in the Grove or Bunsen cell. This double process requires no expenditure of energy.

In the next paragraph Mr. Reed says that my statement that the Jacques cell does not require the continuous application of heat, applies also to any other thermo-electric couple. This is not true. Any true thermo-electric couple does require the continuous application of heat, not only the equivalent of the electrical energy developed, but more than the equivalent, in the proportion required by the second law of thermo-dynamics, and this in addition to the heat lost by radiation and conduction. In any true thermo-electric battery which has come to a fixed temperature on open circuit, the hot junctions will be cooled and the cold junctions warmed as soon as the circuit is closed. To maintain the original temperatures would require the supply of more heat at the hot junction and a more effectual cooling of the cold junction.

Mr. Reed says that the introduction of cold air into the Jacques cell is sufficient to maintain the temperature difference, but he has not shown that the introduction of cold air is necessary, and I venture to predict that the same action will occur in that cell if the air be heated, before it enters the cell to a temperature higher than that of the bath.

Again, Mr. Reed says that the flow of current would transfer heat and maintain a difference of temperature. But if this were true the difference of temperature produced would be such as to develop an opposing E. M. F.

Mr. Reed's assumption that the potential difference found when two electrodes of the same metal are maintained at a difference of temperature in an electrolyte is thermo electric is purely gratuitous. At different temperatures the same metal exhibits different chemical affinities and would behave in the electrolyte exactly as two different metals. This has been well shown in an article in the *Zeitschrift für Elektrochemie* for Feb. 20, 1897, by C. Liebenow and Dr. L. Strasser.

In this article it is clearly shown that the observed potential differences are due to chemical affinities and not to differences of temperature, except as these affinities depend on differences of temperature.

The experiments described in the article also show that the oxygen in the Jacques cell is a depolarizing agent, performing an office entirely similar to the nitric acid of the Grove element. This is exactly what should have been expected from the analogy between the Jacques and all other chemical elements.

New York. WM. A. ANTHONY.

To the Editor of American Electrician:

The contentions of Prof. Anthony in the above communication are not clear to me, unless he means that the Jacques cell is a galvanic battery in which the electrolyte undergoes no chemical reaction, except combination with carbon dioxide; that the electrical energy is due in part to the direct combustion of carbon and free oxygen, instead of oxygen derived from the decomposition of the electrolyte, and in part to the secondary reaction between the product of combustion, CO_2, and the alkali hudrate. In other words, I understand that the two elements, carbon and oxygen, combine directly to evolve electrical energy without any decomposition of the electrolyte and that the action is assisted by the secondary reaction between the CO_2 produced and the electrolyte.

I wish to be careful not to misinterpret the meaning of Prof. Anthony's statement, but it seems to me that is what he means. If such is the contention, it is difficult to see how such an apparatus can be called a galvanic battery or its action compared to that of the Daniell, Grove or any other galvanic cell. In all other galvanic cells the chemical changes, which finally result at the terminals, are produced, not by the direct action of the active reagents upon each other, but indirectly through ions furnished by the decomposition of the electrolyte.

In the Jacques cell, according to Prof. Anthony, the function of the electrolyte is not to undergo electrolytic decomposition; but to act purely as a conductor in one operation and as a receptacle for byproducts in a subsequent reaction. The mere discussion of the merits of such a

theory would be unprofitable. It is sufficient to say that it is a new theory of galvanic and electrolytic action, according to which the electrolyte is an inert conductor, taking no part in the chemical reactions.

My contention was that the Jacques cell does not evolve electrical energy by galvanic action—that is, that the energy does not come from the chemical reaction between the carbon and the electrolyte without the absorption of external heat. That contention was based on the following facts:

The only reactions, by which the oxidation of carbon in the Jacques cell to carbon dioxide by the electrolyte may be supposed to take place are:

(1) $C + 2HOH = CO_2 + 4H.$
(2) $C + 4KOH = CO_2 + 4K + 2HOH.$
(3) $C + 2FeO = CO_2 + 2Fe.$
(4) $3C + 2Fe_2O_3 = 3CO_2 + 4Fe.$
(5) $3C + 2K_2O\,FeO_3 = 3CO2 + 2Fe + 2K_2O.$

The first of these reactions cannot take place without the absorption of 41 heat units; the second, 182.2 units; the third, 39.4 units; the fourth, 30.5 units; and the fifth, not less than that required by the fourth. As none of these chemical reactions could take place without the absorption of external heat, the galvanic action could never commence.

Prof. Anthony's theory that the E. M. F. produced by a hot and a cold piece of iron in contact with an electrolyte is due to difference in chemical affinity at the different temperatures, and not due to an absorption of heat, is important, if true. It would follow that if the conditions can be maintained without external loss of heat (such as radiation, etc.), two pieces of iron in contact with an electrolyte, one being hotter than the other (!), would constitute an inexhaustible source of electrical energy, iron being oxidized at one electrode and an equal amount of metallic iron being reduced at the other, the total amount of metallic iron remaining unchanged, while there is a continuous evolution of electrical energy with no absorption of heat. This theory also, and all others leading to an inexhaustible source of energy, I do not care to discuss, believing that *ex nihilo nihil fit.*

Prof. Anthony has misunderstood one statement in my communication. I stated that inclosing an apparatus in a uniformly heated chamber was no evidence that all the parts within the chamber are at the same temperature, and I mentioned, merely as an illustration, the transfer of heat by the Thomson and Peltier effects, saying, "The burden of proof lies, therefore, on those who claim that all the parts of the apparatus were or could be maintained at the same temperature." I did not, of course, mean that the Thomson and Peltier effects were the cause of the current that produced those effects, but stated clearly that "the difference in temperature due to the current of air would be sufficient to produce the observed electromotive force, even if iron had been used instead of carbon." A fair and obvious intopretation of my statements leads to no such difficulty.

Philadelphia, Pa. C. J. REED.

NORTHWESTERN ELECTRICAL ASSOCIATION LA CROSSE CONVENTION

WHILE the attendance at the La Crosse convention of the Northwestern Electrical Association, held July 21 and 22, was not as large as usual, the number of central station managers and owners present was yet very satisfactory. The contingent of supply-men was large, and though the manufacturers did not as a rule attempt any elaborate exhibits, those on view attracted much attention.

Past-president F. A. Copeland, of La Crosse, took the entertainment of the delegates under his personal charge, and provided a programme that was thoroughly appreciated. Among the features were an excursion in a fleet of launches up the Mississippi, a picnic lunch being served on an island in the river. Colonel Copeland also provided at his own expense a handsome souvenir badge, consisting of a disk suspended from a silver bar, on one side of which was a view of the Mississippi at La Crosse, and on the other an appropriate inscription.

The report of Secretary T. R. Mercein showed the Association to be in a flourishing condition. A valuable report of central station data compiled through Mr. Mercein's efforts had during the year been sold to members at the cost of production; the number of copies having become limited, it was decided by a vote of the members that the price thereafter should be $1.00, and the privilege of purchase be extended to the general public. A vote of thanks was heartily tendered Mr. Mercein for the ability and skill with which he has conducted the affairs of the Association.

The paper which attracted most attention was that by Prof. Shepardson on 220-volt lamps. As pointed out by the author, it was in the Northwest that high-voltage lighting had its rise, the movement dating back a number of years, and it was therefore fitting that the first American paper on the subject should be read before the Association representing that section.

During the convention a correspondence was read concerning an alleged encouragement of the municipal movement by an electrical manufacturing company. In a letter the company defined its position, which is that the company does not solicit business from municipalities proposing to establish plants in competition with existing private plants, and will only enter the field for a contract when a town has been unable to secure a plant by private enterprise, and then only after bids have been solicited by advertisement by the municipality.

Following are extracts of the four papers read before the convention, together with extracts of the discussions on the same.

THE CONSTANT-POTENTIAL ARC.

A paper by Messrs. O. M. Rau and F. A. Vaughn went at length into the subject of constant-potential arcs. It was stated that a light equivalent to forty 16-CP lamps can be obtained from two 450-watt arc lights of the open or enclosed type, fed from the same service as the incandescent light, making a customer's bill about one-half of that for Welsbach lights. It is recommended that small stations pay for arc lamps returned, less 10 per cent. if in good condition. The economy in the production of current in favor of constant-potential over series arc lamps is given as 25 per cent, which, however, may be overcome by loss in the dead resistance and loss in line and feeders, which more costly carbons are required for the first mentioned class of lamps.

It is suggested that disused 50-volt converters may be utilized in connection with constant-potential, alternating-current arc lamps, in which case the lamp should be designed to throw in a resistance or reactance should the carbon points come together and fail to strike an arc. One of the advantages pointed out of the incandescent arc is that, since it feeds very slowly, the flickering and fluctuations of the lamp occur only every three or four hours instead of every five or ten minutes, as in open arcs.

THE METERS OF TO-DAY.

In a paper read by Mr. R. F. Schuchardt the results of tests undertaken by the author and Mr. Geo. H. Jones on meters was given. The results obtained show that meters of the present day are not all that might be desired, and central station men are advised to add a meter-testing department, and to inspect every meter once in six months. The method given for calculating the error of a meter is as follows:

The speed of the meter is directly proportional to the load and therefore, for a given load, the product of seconds per revolution of the armature and of the amperes (for ampere-hour meters), or watts (for watt-hour meters), gives a constant, K, which varies with the make and size of meter. As will be seen, this K is the time in seconds which it takes for the armature to make one complete revolut'on per unit of load (ampere or watt).

The product of the observed load and seconds per revolution (amp. $\times$ sec. or watts $\times$ sec.) divided by this K, should then equal unity for an accurate meter, and the variation from unity will give directly the error. Should this quotient be more than unity, the meter runs too slowly on that load; and if less than unity, the error will be negative, which means that the meter is running too fast. Thus, let the time per revolution be 4 seconds for a load of 440 watts on a 10-ampere, 100-volt Thomson wattmeter. The value of K for this meter is 1800; then, $\frac{4 \times 440}{1800} = .978$, which shows that the meter runs 2.2 per cent. too fast on that load; or,

let the time per revolution of the armature be 2 seconds for 3.3 amperes on a 20 ampere Shallenberger ampere-hour meter in which the value of K, is 6.33; then $\frac{2 \times 3.3}{6.33} = 1,042$, or the meter is therefore 4.2 per cent. slow on that load.

Of the different meters tested, one started much too slowly and was also too slow at high loads. The error at full load between frequencies of 60 and 130 was found to be as high as 30 per cent. for this meter. Another meter built for the two frequencies of 60 and 130 ran with an average difference of about 6 per cent. between frequencies. Some of the other meters started too slowly, but all were practically unaffected by changes in voltages likely to occur in practice. The general results of a test made of meters in actual service were that the ampere-hour meters require a comparatively large current to start them, and run much too slowly at starting and on higher loads, most having a considerable error on overloads. Wattmeters are somewhat better, and as a rule run too fast on all loads except at starting, but with a fairly uniform error.

Attention is called to the necessity of proper installation of meters, which should be securely fastened to a firm wall in a readily accessible and dry place, and well leveled. The case should be dust-proof. Among the requirements of a meter are that it should be accurate within 5 per cent. on all loads and begin to register on at most 1 per cent. of its full load; the power absorbed should not exceed 2 watts per 10 amperes capacity, and the drop through the meter should not be larger than .5 volt; meters should be direct-reading, have no electrical contact makers, and delicate mechanism should be avoided.

In the discussion figures were given showing that the watt loss in different meters varied widely. The figures for three 15-ampere meters, for example, were .4, 1.12 and 1.75 watts, respectively, at a frequency of 130, the two first mentioned having a loss of 5.16 and 4.7 at a frequency of 60. The loss of a 5-ampere meter was 2.65 watts at a frequency of 130, and 6.9 watts at a frequency of 60, and the figures for two 25-ampere meters were 4.9 and 11.2 at a frequency of 130—the voltage in all the above cases being 100.

Mr. Doherty added that there is no marked uniformity between any meters of any make that he had ever seen.

UTILIZATION OF EXHAUST STEAM.

In a paper with the above title, Mr. George T. Thayer gave an outline of the several different systems of utilizing exhaust steam, and data as to cost and the quantity of steam required to heat given spaces.

Mr. Thayer does not favor the plain gravity system of distribution, considering that it is necessary to have vacuum circulation in order to reduce the back pressure on the engine. A gravity system can be changed into a vacuum system and the coal consumption reduced considerably with better results in heating.

The design and construction of underground mains should be such that the radiation losses are small, falling within 5 per cent.; expansion and contraction should be provided for and the mains should be protected from the surface water to prevent corrosion. In one standard method of construction, at the bottom of a trench is laid a tile drain and the iron pipe with its covering is within bored pine logs tenoned together, and the outside surface of the logs painted with asphaltum. Expansion is provided for by a special fitting having a flexible diaphragm, thus doing away with the stuffing box. Service connections are made every 50 ft. In another method the pipe is supported a few inches above the bottom of a box made of tarred boards, the box being filled with asbestos wool or the pipe covered with ordinary pipe coverings. The rates and method of charging for central station heating vary considerably, the tendency being to charge according to the space to be warmed rather than by the square feet of radiation. In Western territory the amount charged should be from 10 to 20 per cent. higher than the cost of heating the same space with hard coal, owing to the advantages offered.

A list of rates charged by different plants is given. In one the charge for a 20 × 90 store room is $60, for a 15 × 20 office, $20; for a 20 × 30 bank, $40. In another instance $50 is charged for a 22 × 60 store. A third plant charges $20 per 1000 cu. ft. for brick stores and $3.50 per 1000 cu. ft. for dwellings. In another $100 to $125 per year is charged for a ten-room house. In a fifth plant the charge is twenty-five cents per square foot per year, and in a sixth it is $3.50 per 1000 cu. ft. of space, the heating being done by live steam on the meter system.

Profitable heating is that which can be taken care of during the greater part of the evening load. It can safely be assumed that at the peak of the load more steam will be used by the engines than can be discharged into the heating system. A storage battery can be used to take a portion of the load during this time and later in the night when heating otherwise would in part be with live steam, the battery can be charged at a very small expense for fuel.

Mr. Thayer replied to an enquiry as to the cost of a heating plant, that the auxiliary apparatus and power house will cost about $5000 and the additional expense of installing the apparatus about $20 per HP. Figuring on the basis of 100 HP, the income would be $2500 after the mains were fully loaded up. A 6 or 8 in. main costs nearly a dollar a foot to lay. The depreciation may be as high as 20 per cent., but it is claimed that under good conditions a plant will last twenty years, and Mr. Thayer stated he knew of underground mains that are still in good condition after fifteen years of use. As to profit, if there is a day load, say, of 100 HP, and an evening load of 500 HP, the expense will be the interest and depreciation on the mains, which is comparatively small. If live steam is furnished, no profit can be made. One of the members thought that more could be gained in the case of his station by condensing than by selling exhaust steam.

220-VOLT LAMPS.

A paper by Prof. George D. Shepardson, with the above title very thoroughly considered the subject from several standpoints. As to the present status of 220-volt lamps, he said that reports from the plants installed are almost invariably encouraging, whether coming from managers or patrons, and that the common verdict that it is the best system extant must be accepted as proof positive of good, reliable service and of a good reputation at home. It should be borne in mind, however, that much of the praise comes from those who have had little or no experience with other lighting systems.

The advantages of using high-voltage lamps lie in the less amount of copper that may be used and the extension of the area that may be lighted. It is now well understood that 125-volt systems cannot economically serve districts of more than 1000 ft. radius from the station, the three-wire and alternating systems having formerly had the field to themselves where the districts were larger. The low all-day efficiency of the latter and the patent control of the former, have been the causes of the high-voltage lamp coming forward. Almost all small cities and villages installing new plants now adopt the 220-volt direct-current system, while a few years ago the alternating current system had this field almost to itself. Companies using the three-wire system have also found in the 220-volt lamp the possibility of extending their lines and operating motors at 440 volts instead of using a special 500-volt system.

While the 220-volt lamp is less efficient than the 110-volt lamp, this lack of efficiency admits of a larger drop and consequently reduces the weight of copper even less than one-fourth. Comparing 110-volt and 220-volt systems with equal percentage drop, the variation of the light from 220-volt lamps is hardly noticeable when that of the higher efficiency 110-volt lamp is intolerable. The conclusion of Prof. Shepardson is that a 220-volt system requires considerably less than one-fourth the weight of copper required by the 110-volt system serving the same district with equal satisfaction to users; and that the great saving in copper easily balances the increased cost of the larger generating plant and of the larger amount of fuel.

The greater portion of the paper gives details of tests of 220-volt lamps. Of four groups of lamps tested the initial CP varied from 13.6 to 19.8, though each lamp was rated at 16 CP. The general average for one group was 13.6 CP at the beginning, rising to 13.8 CP in 90 hours and gradually falling to 11.9 CP in 921 hours. The general average for another group was 19 CP in starting, falling off to 14.2 CP in 90 hours and to 11.4 CP in 921 hours. The general average for a third group was 15.6 at starting, falling off to 13 5 CP in 90 hours and to 13.4 CP in 920 hours. Each of these groups contained some poor lamps which lowered the average, the results of good lamps being much better. For example, in the first mentioned group, a good lamp started off at 13.9 CP, rising to 15.4 CP in 90 hours, and then falling off to 13.8 CP in 921 hours. The same lamps started at an average of 4.6 watts per candle, improving to 4.45 watts in 30 hours and increasing to 4.8 watts in 90 hours and to 4.94 watts in 921 hours. The general average at starting of all groups, including bad and good lamps, was 4.6, 4.3, 4.6 and 5.5 watts, respectively;

and 6, 5, 5.5 and 5.8 watts at the end of 921 hours.

The tests extend over 921 hours, and the conclusion is that if a lamp is hung vertically, it will last 1000 hours or more if it lasts ten minutes. It is suggested that the size of globes of 220-volt lamps might be increased to advantage.

Prof. Shepardson appends to his paper some reports from 220-volt municipal plants in Minnesota. At Adrian the plant has been operated two years with entire satisfaction. 480 incandescent lamps are used in stores and 110 in residences, the meter rate to consumers being 8½ cents per KW-hour. The plant is run in connection with the water-works.

At Wells, Minn., a 220-volt plant has been operated two years with good satisfaction. 900 16-CP lamps are used in the stores and residences and 25 for street lighting, the meter rate to consumers being ten cents per KW-hour. At Lake City a 220-volt plant has been operated 1½ years with entire satisfaction. There are 850 incandescent lamps installed for inside lighting, the meter rate to consumers being ten cents per KW-hour.

A 220-volt plant has been operated at Windom, Minn., one year with good satisfaction. Forty incandescent lamps are used for street lighting and 700 installed in residences. The meter rate to cousumers is ten cents per KW-hour.

All the above are municipal plants, owned and operated by the cities.

In the discussion Prof. Shepardson referred to the fact that a large amount of the praise that comes to the 220-volt lamps is due to the fact that, being necessarily run at low efficiency, the light is more uniform. Of the lamps tested, the initial candle power varied at the start from 13.6-CP as the average of one lot, to 19.8-CP as the average of another lot, all the lamps being marked 16-CP.

Mr. Doherty suggested that a plan for testing 220-volt lamps in which 110 and 220-volt lamps would be burned, the same number of hours on the same mains, but at their respective voltages, thus giving comparative results. Commenting upon this, Prof. Shepardson stated that you can get from the same manufacturer a lamp that is 2½ or 5 watts, though both may be represented to be of the same efficiency; that is, the result would be only one particular 220-volt lamp compared with a particular 110-volt lamp, but would tell nothing with respect to the general run of lamps and their comparative merits. Mr. McGill stated that his company (Siemens & Halske) are pioneers in the use of the 220-volt system, which they claim to be more economical than the alternating system under certain circumstances and conditions. For a distance of not more than 1000 ft. the 110-volt system is preferable, but there is no comparison made between that system and the 220-volt system for distances of 3000 or 4000 ft.

NOTES.

Electric Transmission in Maine.—It is proposed to transmit 5000 HP to Portland, Me., at high voltage from the Presumpscot River near Gorham. The head of water will be 22 ft. at one dam and 27 ft. at another. The distance is less than 20 miles. Mr. George W. Brown, of the Belknap Motor Company, is one of those interested in the project, which is now under way.

The St. Lawrence Power Company.—Work has been commenced on the canal of the St. Lawrence Power Company, at Massena, N. Y., 700 men being now employed, and it is expected that 3000 will soon be at work. The plans for the canal contemplate a discharge of 1,500,000 cu. ft. per minute, surpassing anything heretofore attempted in hydraulic engineering. The contract for the fifteen generators of 5000 HP each, has, as previously been announced in these columns, been let to the Westinghouse Company.

Underground Cables in St. Louis.—The placing of telephone wires underground in St. Louis recently led to the largest telephone cable contract ever given in this country, and probably in the world, amounting to 650,000 ft. of cable, containing no less than 100,000,000 ft. of No. 19 B. & S. copper wire and 2,000,000 lbs. of lead. The cable will be of the usual paper-insulated type, and was ordered by the Bell Telephone Company of Missouri, and the Kinlock Telephone Company from the Standard Underground Cable Company, of Pittsburgh.

The New Tariff.—Among the provisions of the new Tar ff is an increased duty on incandescent lamps which will prevent further importations, and the same is true of arc light carbons. The previous duty on such carbons was in litigation, 20 per cent. being claimed by importers and 30 per cent. by custom house officials. The latter duty was incorporated in the new tariff bill when it went into conference. By a change in phraseology, the bill as it came out and was passed, imposes a duty which is said to average more then 150 per cent., all sizes of carbons being considered. Senator Hanna, it may be remarked, is connected with the carbon trust.

Underwriters' Rules.—The National Board of Fire Underwriters has issued a new code of insurance rules,being the National Electrical Code compiled by the National Conference on Standard Electrical Rules, the membership of which represented the various electrical,insurance,and architectural interests. The arrangement of the new code differs somewhat from the one which it supersedes, making it difficult to determine what changes and additions are embodied. We note that the quantities in the table of carrying capacities of wires have been slightly changed. The arrangement of matter and cross-references have been considerably improved. As these rules without doubt will apply to every part of the United States, a copy should be in the hands of every one doing electrical construction work. The pamphlet may be obtained by application to any one of the various tariff associations.

An Eighty-Mile Electrical Transmission.—A contract for the transmission of power from a river running through the Santa Ana Canyon to Los Angeles and Pasadena, Cal., a distance of 80 miles has been concluded, the amount of power to be transmitted being 4000 HP to commence with. The station will be located in the Santa Ana Canyon, 12 miles from Redlands and about 80 miles from the towns in which the electric power will be utilized. The water will be taken from the river through canal, flume and tunnel along the side of the canyon, and then led into a pipe line 2200 ft. long, giving what will be equivalent to a vertical fall in the water of 750 ft. The wheels will be of the impact type, directly connected to General Electric generators, of which there will be four, each of 750-KW (1000-HP) capacity. The maximum line potential will be 33,000 volts, to which potential the initial voltage will be raised by twelve 250-KW step-up transformers. This transmission will be the longest commercial electrical power transmission yet undertaken, as well as that using the highest voltage. At present the longest is that transmitting the power of the waters of the Ogden Canyon in Utah to Salt Lake City, a distance of 36 miles. The Los Angeles transmission will, be over twice that distance, and three times the longest distance to which Niagara power is transmitted, which to date is only to Buffalo, a distance of 26 miles.

What is Electricity?—In an appreciative review in London *Engineering*, of Prof. Trowbridge's book, "What is Electricity," the writer says that in spite of the all-round progress made during the last 30 years, we know no more about the essential nature of electricity than did Benjamin Franklin 150 years ago. The several explanations offered, based upon the ether, or ether and matter associated, merely substitute one unknown for another. "After all, what is matter? What is the ether? How is matter associated with the ether? To such fundamental questions we can return no other answer than the now famous *ignoramus*. They make, or tend to make us painfully conscious of the infinitude of our nescience." The writer of the review adds that Lord Kelvin must have been brooding over these provoking unknowns when he wrote to him in 1892, "Tell me what electricity is, and I'll tell you all the rest." This inability to detect electricity in its primordial form need, however, exert no distrustful, no depressing effects on the mind of the student of physical science. "Let him remember that a ray of light is an unexplained phenomenon; yet what wonderful truths is revealed to Fresnel, what knowledge has been wrested from it by means of the spectroscope, and what marvels is it not every day recording on photographic plates! If he feels himself morosely affected by this agnosticism, let him recall the astronomical phenomena which are accurately calculated years in advance without any knowledge whatever of the nature of gravitation; or let him think of that masterly bit of analysis which led to the discovery of argon without any knowledge on the par of Lord Rayleigh or Prof. Ramsay of what chemical affinity is. If he is a practical man, let him reflect that the engineer lives amid stresses and strains, and though ignoring the intimate nature of the forces which he uses, builds up powerful engines and dynamos, and as successfully tunnels a Mont Cénis as he throws a bridge across the Hudson or the Firth of Forth."

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Fuses vs. Magnetic Cut-Outs.

Of late years the fusible cut-out has been having a sorry time of it. Its unreliability has been a safe topic for the writer lacking other subjects, its denunciation, like municipal ownership, being popular on all occasions. It has been accused of making invidious distinctions between direct and alternating currents, of permitting its relations with its terminals to affect its efficiency, of having a propensity toward arson, of becoming decrepit at too early an age, and of being generally capricious and inconstant. Per contra, the magnetic cut-out has been held u[illegible] free of all the vices of its rival and possessing besides many virtues peculiarly its own. Elsewhere in this issue we print an article in which the cudgels are taken up in defense of the much-abused fusible cut-out, and, most singularly, by a manufacturer of magnetic cut-outs.

That a fusible cut-out may be so constructed and installed as to lessen the objections that have been urged against it, is undoubtedly true. Much of the criticism to which this type of cut-out has been subjected has been unfair in that the tests upon which they have been based were made under conditions as to length of fuse and method of connection that necessarily involved inefficient action. These conditions, it is true, were those of current practice, but nevertheless distinctly unfavorable to the fuse. On the other hand, the magnetic cut-out with its absolutely positive action and exact time element, has such incontestable advantages as a circuit interrupter that—however hazardous it may be to differ with one so well qualified on the subject as the writer of the article—we cannot agree with his conclusion that their use constitutes a step backwards in electrical progress.

Another Great Patent Invalidated.

The United States Circuit Court of Appeals, sitting at New York, has rendered a decision which practically annuls the Van Depoele fundamental claims to the invention of the overhead trolley, though the patent upon which these are based had previously been sustained in other courts. The Van Depoele claims to the invention of the overhead trolley rested upon two patents, one issued in 1890 and the other in 1893. The former relates to details of trolley mechanism and the latter is a generic patent covering the overhead trolley as a whole and fundamentally. The opinion of the court is to the effect that although the earlier patent contains matter of disclaimer inserted for the purpose of making the later patent ostensibly the generic one so far as it relates to the contact devices, such matter is antagonized by, and is wholly inconsistent with, some of its claims. The court holds that the changes in the phraseology between the two patents import nothing of substance into their respective combinations; that they describe the same things in different language, and "the draftsman seems to have expended gratuitous ingenuity in cataloguing a group of synonyms."

In other words, it is held that the earlier patent anticipates the later one. Unfortunately, however, for those owning the Van Depoele patents—but fortunately for the electric railway industry as a whole—the earlier patent can extend no protection beyond the specific features which it claims, and these are not vital to the operation of the trolley. The United States Circuit Court of Appeals has final jurisdiction in patent cases, with the exception that the Supreme Court may order a case before it for reconsideration, but its action on this point is entirely at its own discretion, which discretion is rarely exercised. Another Circuit Court of Appeals, may it is true, take a different view of the validity of the patent and its decision would then apply to the territory over which it holds jurisdiction. A case to point was the decision of Judge Ricks in the incandescent lamp case, which conflicted with that of another court, the result being that incandescent lamps could be manufactured and sold with impunity within the jurisdiction of Judge Ricks' circuit. As the decisions of the Circuit Court of Appeals in the Second District, however, have great weight, one of its members being Judge Lacombe, who is perhaps the strongest member of the Federal judiciary not on the Supreme Court bench, the chances are strong that the decision will not be overruled elsewhere. As to whether the Supreme Court will take action, is problematical. If it does not, the present decision remains final, as there is no right of appeal. This is almost the last of the great electrical patents, the only other of unusual importance being the Tesla polyphased patent of 1888.

Signaling by Hertzian Waves.

The account printed in our July issue of Marconi's apparatus for transmission of signals through space by means of Hertzian waves, should have been supplemented with the statement that to earlier experimenters is due the discovery of the principles upon which the method rests. The transmitter used is a simple form of Hertz radiator, but with a layer of oil interposed between the knobs in order to keep the polished surfaces of the latter in good condition. The coherer tube is merely a Branly coherer of the kind described by the French savant in 1890. The combination of the radiator and coherer was applied to transmit signals through space several years ago by Lodge. To Marconi is due, however, the great credit of devising a practical apparatus which, if not yet commercial in form, gives much promise of becoming so.

The principles utilized in the apparatus and their mode of action are surprisingly simple. The history of so-called Hertzian waves dates back to the discovery of Faraday that the properties of a ray of light are changed when it passes through certain media subjected to the influence of a field of force. Taking this phenomenon as a starting point, Maxwell developed his great theory of the wave propagation in the ether of electrical disturbances, which he demonstrated mathematically was by waves simi-

lar to those of light waves, the speed of propagation being identical. This theory remained a mere abstraction until the magnificent experimental work of Hertz during the years 1887-89. Hertz not only verified Maxwell's theory, but measured the length of electric waves, and refracted and reflected them in the same manner as light. In 1890, Branly discovered a sensitive detector of electric waves, consisting of a tube of fine metallic filings, the resistance through which, ordinarily very high, becomes very small when exposed to the influence of electric waves.

We can now easily understand the operation of Marconi's apparatus. Whenever there is an electrical disturbance, waves in the ether are set up and propagated with the velocity of light, or 185,000 miles per second. For example, from a conductor carrying an alternating current of a frequency of 60 cycles per second, sixty waves are sent forth in a second, each having a length of 3100 miles. As the frequency is increased the wave length is diminished, and by means of the rapid oscillatory discharge of an induction coil or a Leyden jar, may be made very small. Waves as small as 8 ins. have been measured, which corresponds, of course, to an enormous frequency. For obvious reasons, only the smaller waves can be detected, those employed by Marconi being about 50 ins. long. It has been found that for uniformity of effect the surfaces between which discharges take place should be kept highly polished in order to obtain uniform effects, and this Marconi accomplishes by surrounding the surfaces of the sparking balls with oil.

The waves sent forth by the spark from the induction coil used by Marconi fall upon a Branly tube, causing the filings to cohere and thus enabling a current to pass through them. This current is that of a local circuit containing a sensitive relay, which in turn may work a sounder or Morse tape register. One of the details consists of a tapper worked from a local circuit, which causes the filings through vibration to "decohere" when no longer subjected to electric waves, the resistance of the tube then becoming so great as to prevent any appreciable current to pass. We thus see that if there is a key in the primary circuit of the transmitter current, whenever it closes the primary, electric waves are sent forth, which cease as soon as the primary is opened. On the other hand, as long as electric waves continue to impinge on the filings, the relay circuit is closed, and it opens when the waves cease. Therefore, by operating the key of the primary, a sounder or register is operated in the same manner as if these apparatus were in an ordinary telegraphic circuit. A recent cablegram reports that Marconi with his apparatus has in the manner above outlined, transmitted intelligence through space over a distance of 12 miles.

Municipal Ownership.

The agitation in favor of the municipal ownership of electric light plants is undoubtedly still on the increase, and recently has been coming to the front in New York City politics. On the other hand, so far as we can see, about the only resistance opposed is of the kind which in the past has proved so impotent, consisting merely in denunciations of the advocates of municipal ownership, or arguments based upon legal or ethical grounds that have little or no weight with the average voter—either through mere indifference or because he considers them ex parte, or he has adopted as a matter of political faith the doctrine attacked and is therefore deaf to reason. The most pernicious line of defense has been that in which the motives of those favoring municipal ownership have been indiscriminately denounced as corrupt, and the administration of municipal enterprises pronounced to be necessarily dishonest. However much truth there may be involved in such charges, the former only renders advocates of municipal ownership more rabid without appreciably affecting public opinion, and the latter, particularly in smaller communities, is apt to be resented as an attack on popular government.

The only line of argument which appeals most directly and almost equally to all classes, and to which even the most bigoted will lend an ear, is the one which has either been entirely neglected or presented in such form as to be shorn of its power—the argument of dollars and cents, in the form of carefully compiled data on the cost of municipal lighting from present plants presented in such shape as to admit of easy verification It is true, some compliations of the kind have been made, but the form has rarely been satisfactory, sometimes through betraying too partisan a bias, and again by merely forming part of an arraignment of men and doctrine that nullifies the intended effect. It would be a praiseworthy task for one of the electric light organizations to prepare a model form carrying the different heads under which the charges against electric lighting should be classified, such as, interest, taxes, water, superintendence, depreciation, repairs, labor, fuel, etc., with a line opposite each item giving the authority for the value quoted. The only comment necessary would be a simple comparative statement of the charge for lighting privately owned plants in the neighborhood of the town under consideration.

It may be said that in some cases such a statement would work injury to privately owned plants enjoying rates that would not admit of favorable comparison. The reply would be that where a great industry is threatened as a whole or in great part, some sacrifices must be made in its defense. Under proper management a privately owned plant, if effectively installed and competently managed, should be able to operate in competition with a corresponding municipal plant, and obtain a good profit from the margin which must always exist through the greater incentives incident to private enterprise. If it cannot do so, there is a lack of ability on the part of the management or the plant has not been efficiently kept up, and the sacrifice for this condition should not fall upon the cause at stake. To deny that a margin of profit should not exist in favor of the privately owned plant is to affirm that business principles do not apply in the branch of industry under consideration. In labor there would be a most marked difference, both in quantity and price. In purchases the buyer spending his own money would take advantage of that margin between asking and bottom price which, in lines of business where competition is fierce, very often furnishes the entire source of profit. Eager to extend his gains, the private owner worthy of success would be keenly alive to every improvement, both in operation and apparatus, promising increased economy.

In other words, a privately owned electric lighting company under proper management can take advantage of innumerable opportunities for cheapening the cost of its product which are denied to the management of a municipal plant, handicapped as such an enterprise is by lack of incentive; maximum market rate for labor; delay or refusal of appropriations to secure increased efficiency; higher price for material and supplies, due partly to the open manner in which purchases are made and to the fear of misconstruction by the agent should he desire—which is unlikely—to enter into confidential "deals" for lower prices; impossibility of adjusting discounts according to the value of consumers' business, etc. These and doubtless many other reasons that might be offered would, if arguments are to be relied upon, carry conviction where constitutional and ethical pleas would have no avail, and where charges of personal corruption and implications against the operation of popular government would only excite resentment.

SECTORLESS WIMSHURST MACHINES.

BY S. M. KEENAN.

There exists a prevailing idea that sectors are absolutely necessary on a Wimshurst influence machine, while in point of fact they are somewhat of a detriment when a large output and long sparks are required. The only objection to sectorless machines is their inability to self-excite. This is a minor consideration in a large machine, as a charge is readily imparted and can be retained, often for hours, while the machine is idle. A rod of vulcanite, gutta-percha, glass, wax, etc., excited by any of the well known methods, and held opposite the neutralizer easily imparts a charge. Any particular sign can be given to either side. If the machine be encased and it is not desirable to open the case, a small self-exciting machine may be placed in the case or under it and proper connections made with the prime conductors. These connections, likewise the attachments for imparting motion to the exciter may be controlled from the outside. Similar arrangements are made use of by Waite & Bartlett, by Van Houten and by Ten Broeck to excite their large Holtz machines.

The only requirements necessary to change a sectored to a sectorless machine is to attach several brushes or points to each section of the neutralizer and discard the sectors. It makes little difference whether brushes or points are used, the results are about the same. When brushes are used they gradually wear off and require renewing, whereas points are free from this objection as they do not touch the glass. Points, however, require very careful adjustment, particularly in large machines with multiple plates, as they are liable to scratch the shellac off the plates or perhaps fracture them. The more of the radial surface brushed or that passes in front of the points, the greater the output. There is, however, a limit, as a spark is liable to jump from one collector to the other by way of the neutralizer if the end of the latter is very near the center. A little experimenting will soon give the proper positions. To adapt the machine for the production of long, thin sparks, or short, thick ones, it is well to provide adjustable neutralizers and collectors.

The first published notice of a sectorless Wimshurst appeared in *La Nature* Apr. 14, 1894. The machine therein described is the embodiment of an idea suggested by M. Pellissier in 1891 in the *Journal de Phisique*. This machine, constructed by Mr. Bonetti, appears to have been preceded by one made by A. J. Picolet. The essential features of both are the same, the only difference is that Mr. Bonetti used several brushes on the neutralizer, while Mr. Picolet employed points. Mr. Bonetti's machine measured by a Lane electrometer, according to the authoritative statement of Mr. D'Arsonval, who carefully tested it, "gives a discharge three times greater than a machine of similar dimensions provided with sectors." Illustrations and full descriptions of Picolet's and Bonetti's machines may be found in the *Scientific American*, May 26, 1894.

The writer was constructing a two-plate, 18-in. machine, when the description of Bonetti's machine appeared, and decided to try it before the sectors were placed on the disks. A rubber comb passed through the hair once or twice excited the machine, but the discharge was insignificant due to the small surface brushed, there being employed but the four brushes as used on the sectored machine. When the room was darkened the glow appeared only in the region of these brushes. A wire was then passed diametrically across the plates on each side

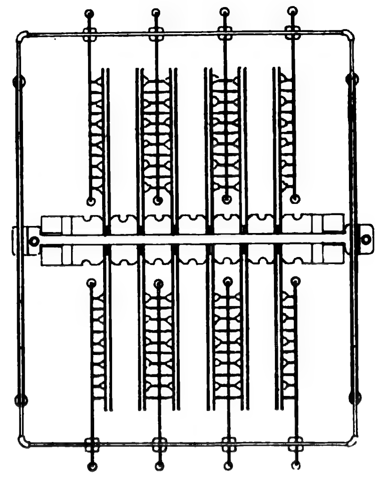


FIG. 2.—SECTION OF NEUTRALIZER.

and fastened to the ends of the neutralizing rods. Tinsel brushes were attached 1 in. apart on the wires and pressed gently against the glass. By this arrangement almost the entire surface of the disks was brushed. Upon exciting the machine the effect was magnificient. Powerful sparks 8 ins. long passed between the knobs.

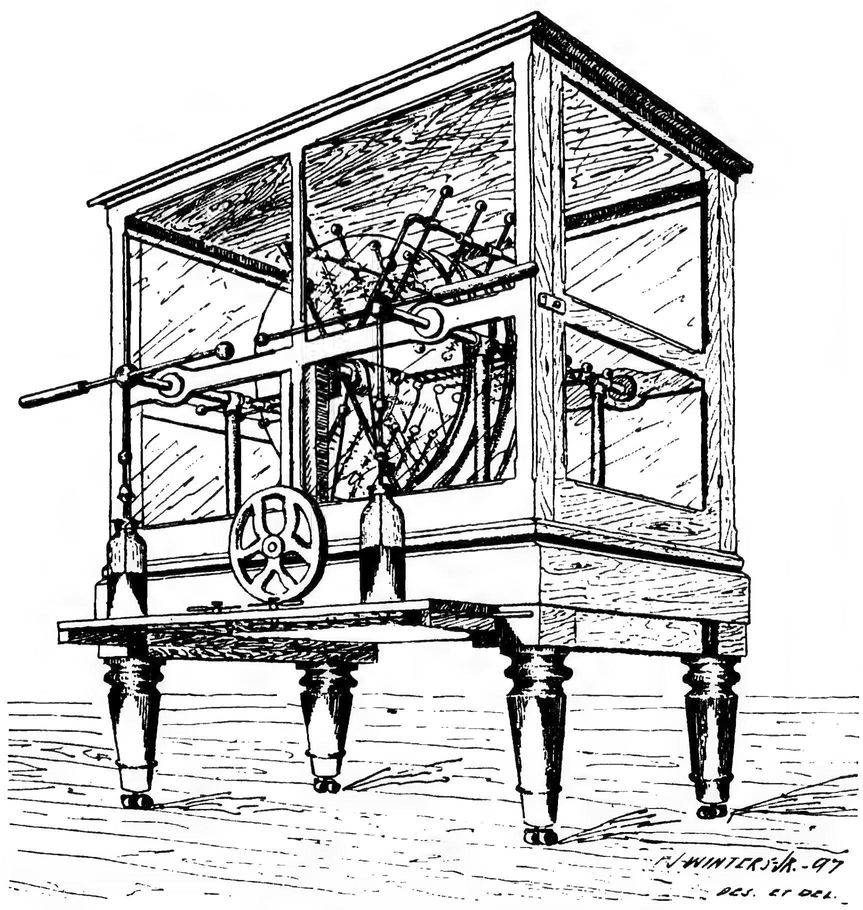


FIG I.—SECTORLESS WIMSHURST MACHINE.

An adjustable neutralizer has been substituted for the temporary wires. This machine never fails to work when a Voss or regular Wimshurst will excite. Some days during the summer when the atmosphere is very humid it will not work, nor will any other unless it be encased and drying material placed in the case. Under similar conditions, with an exciter in the case, a sectorless machine will work during any weather. There are two sets of plates for this machine, one with and one without sectors. But a few moments are required to change it from one to the other. Careful comparisons have been frequently made with the result always greatly in favor of the latter.

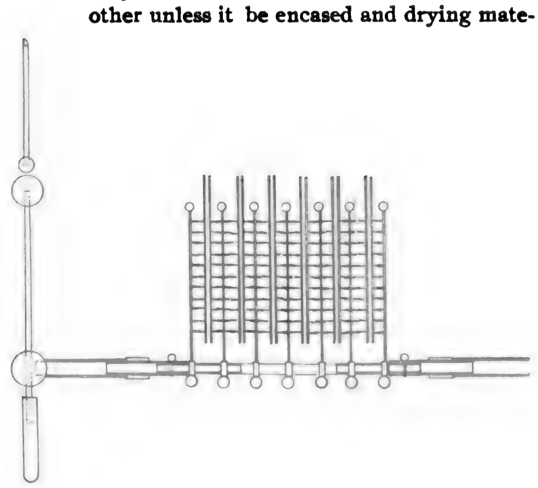


FIG. 4.—SECTION OF COLLECTOR.

A 40-in., two-disk, sectorless machine was constructed last year for Röntgen-ray work, but it is not suitable for exciting Crookes tubes, owing to the small output in current. Two things are essential for exciting Crookes tubes with a static machine—multiple plates

or very high rotary speed. As 40-in. glass disks cannot be thus rotated, it can easily be seen why this machine is unsuitable for Röntgen experiments.

The writer has lately constructed a twelve-plate, 32-in. diameter, sectorless machine, which answers so perfectly every purpose of experiment and electro-therapeutics that a brief desciption may prove of some interest. Fig. 1 gives a general idea of the machine, with the exception of the exciter, which is not shown in the sketch. The driving pulleys and bosses are the same as on an ordinary machine, with the exception that the steel shaft for the pulleys turns in roller bearings. The rest of the machine is entirely different from Wimshurst's. The base frame is made of 3½×5½ in., kiln-dried, yellow pine, and mounted on suitably turned legs. This base gives a very firm foundation to the machine and prevents the glass case from shaking when the machine is working. Two uprights are bolted to the inside of the side pieces, and are slotted at the top to receive the steel shaft carrying the plates.

Fig. 2 shows a section of the adjustable neutralizer. This consists of a rectangular frame that passes entirely around the plates and is mounted on the disk-shaft by double knobs. These knobs are tapped for a piece of tubing the same size as the bushing of the bosses and serve as bearings for the shaft. Taper-bored ball nuts are fitted on each end of the cross arms, and hold the transverse rods near or remote from the edges of the plates. The radial rods that carry the brushes are mounted on the transverse rods by cross-bored knobs that slide on the transverse rods. By means of set-screws these knobs may be set in any position; likewise the radial rods. By this combination, which was made purposely for wide adjustments in experimenting, the neutralizers may be placed at any angle, the radial rods may be all raised or lowered together or separately, and, in fact, any adjustment desired may be made in a moment. This rather complex neutralizer adds considerably to the expense of the machine, but is very desirable when careful investigations are required. The radial rods carry alternate brushes and points set 1½ ins. apart, and brush any portion or all of the plate, as desired. The brushes and points are interchangeable, and hence brushes alone, or points alone may be used.

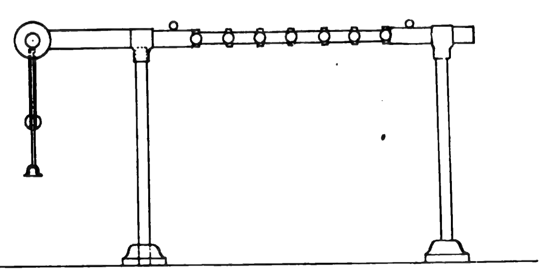


FIG. 4.—SECTION OF PRIME CONDUCTOR.

The prime conductors (see sections, Figs. 3 and 4) are supported on vulcanite posts, and the discharge rods fitted into either ends of these conductors, affording the use of the dischargers from either side of the machine. The collecting combs are adjustable up, down and sideways on the prime conductors. As window glass plates of large size are more or less "dished" this arrangement of the collecting combs is desirable owing to the fine adjustment it affords.

The Leyden jars may be placed inside the case or outside on a movable shelf. The external coatings of the jars are connected underneath the shelf by a sliding switch, that protrudes therefrom close to the hand of the operator, enabling him to produce the spark or brush at pleasure. Two binding posts are connected to either portion of the switch for adminstering an induced current, or for attachment to the primary of a D'Arsonval or similar high-frequency transformer. These binding posts carry sliding dischargers for the regulation of the induced spark. By these the induced current may be made to assume a continuous or an interrupted oscillation. By them the volume of the direct discharge may likewise be controlled to a nicety. This has been found very serviceable in Röntgen-ray experiments, in conjunction with a regulated spark gap in the main circuit. When a Crookes tube is placed in the direct circuit—the best method by far—and the induced circuit closed, fitful sparks generally pass across the gap, rendering the illumination of the tube very bright but inconstant. If the induced circuit be opened beyond sparking distance, the discharge at the gap will be constant, but often too weak for powerful excitation of a tube of high vacuum. But, if the induced dischargers be separated gradually a point will soon be found at which the tube becomes brightly fluorescent and very constant, giving rise to abundance of Röntgen rays which render quite distinct in the fluoroscope the shadows of the deeply seated bones.

The case is made in two sections and may be removed at pleasure, as the operating parts of the machine are constructed independent of the case. To remove the case the key-bolts for holding the dischargers to the prime conductors are removed and the dischargers taken off, the hooks at the top of the case opened and each half section lifted off the base separately. This is particularly advantageous for the purpose of replacing broken disks.

This machine has been in operation for three months in the Wayne County (Mich.) Hospital, and has given the very best of satisfaction to the physicians in charge. It embodies all the latest features for electro-therapeutic treatment and has proved a valuable remedial agent in many diseases. With suitable Leyden jars it produces powerful sparks 15 ins. long and absolutely deafening. When a patient is placed on the insulated stool, connected with one of the dischargers, and the outside coating of the jars disconnected, powerful brush discharges several inches long and entirely painless may be drawn from any part of his body. For Röntgen-ray work it is excellent. Its enormous output, suitably regulated, renders the largest tubes intensely active with perfect ease. Nor does it dangerously heat up a tube—the great fault of induction coils—after using it constantly for two hours or more the tnbe remains comparatively cool.

There are, no doubt, about this machine many features that may be greatly improved, rendering it thereby much more efficient, for it is exceedingly difficult to construct anything along lines of a radical departure and avoid errors.

TESTING DYNAMOS.

Dynamo testing is a subject of which many electricians or aspirants to such a position have a very imperfect idea. There are so many qualitles for which a dynamo may be tested that the word test, as applied to a dynamo, is very indefinite indeed, unless specifically qualified.

In the large factories where many electricians receive such ideas as they have of dynamo testing, there is usually nothing more done to the machines than to run them at a heavy load for a number of hours in order to develop any weaknesses before the machine leaves the factory. Occasionally, a new type of machine is tested for more important points, but as a rule operation tests are all that are made. The object of this series of articles is to show how the various qualities of a dynamo may be tested and to describe various methods of doing this.

The most important dynamo test is that for efficiency, but even this needs specific definition, for there are three distinct efficiencies to a dynamo. The first is known as the electrical efficiency, and is the ratio of the electrical activity of the external circuit, to the total electrical activity. The word activity, it may be explained, expresses the rate at which energy is expended or created; for example, the activity of a steam engine at any instant is, the rate at which it is working at that instant, expressed in horse power, or foot-pounds per second or minute. This is the highest of all efficiencies and is often used as a figure by which to sell the dynamo, but neglects all iron and frictional losses. The next is the efficiency of conversion or gross efficiency, and is the ratio of the total electrical activity in the circuits, to the mechanical activity given to the dynamo.

The circuits of the dynamo are not all productive of useful work. The field circuit, for instance, absorbs a certain amount of current which is necessary to the operation of the machine, and the armature circuit also receives a certain amount of energy, and these are no part of the working circuit on which the lights or motors are placed. The efficiency of conversion is but little used except in calculation.

The commercial or net efficiency of the dynamo is the ratio of the electrical activity in the external circuit, to the mechanical activity given to the shaft of the machine. This is the important efficiency, for it represents the ratio of the input to the output.

It will be seen at a glance that the energy put into a machine is equal to the energy which is taken out of the machine, plus whatever is lost in conversion; that is, input equals output plus losses. We may determine the efficiency of the machine by measuring any two of these three quantities, and we would naturally select the two that are the most convenient, which will depend upon the conditions under which the test is made.

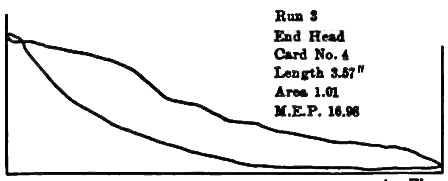
The easiest of these quantities to measure

is the output, except in the case of alternating-current dynamos, for it is simply the product of simultaneous values of ammeter and voltmeter readings, the instruments being properly connected with the terminals of the working circuits. The losses of the machine and the input of the machine are about equally difficult to measure, and it may be convenient to measure sometimes one and sometimes the other. It may be added that the losses may be measured more accurately than the input.

The methods that first suggest themselves to the student are the direct measurement of the output and input and the division of the latter by the former, and such methods will be first discussed.

The Indicator Method. One of the most common cases that is likely to arise is that where a plant is driven by steam engine, either belted or direct-connected. Let us assume that we have a single direct-current dynamo belted to an engine, and that we desire to obtain the commercial efficiency of the dynamo. The necessary instruments are a pair of indicators and a voltmeter and ammeter. By means of the indicators we may measure the input in horse power, and by the electrical instruments we may measure the output in kilowatts, and reducing these two quantities to the same units, we may place them in ratio and get the efficiency.

Although the principle of the method is simple, there are a number of precautions that must be taken in order to obtain an accurate result. The indicators must be adjusted to the engine with the usual precau-



Am.Elec.

tion, the reducing rig must be accurate, and the cards must be taken simultaneously with the readings of the voltmeter and ammeter. At least two men will be necessary to make the test. A log sheet should be prepared as shown hereafter. The dynamo load must be kept constant, for the efficiency of the machine varies with the load. On each test at least ten readings of the instruments and five sets of cards should be taken and the results should be averaged. Cards should be taken simultaneously with readings of the instruments, and endorsed as shown in above cut. The detailed method is as follows. First, the dynamo is allowed to run at the load for which it is to be tested for a number of hours in order to warm up to commercial conditions. This is very important, for the efficiency of the machine may be several per cent. lower when hot than cold. The indicators are adjusted and the instruments connected in circuit. The person reading the instruments should have a gong near at hand by which he may signal to the man at the indicators when to take cards. The cards should be taken every two minutes and the instruments read at the same time until five cards are taken. A set of five friction cards should then be taken, for the cards taken during the test measure the mechanical energy given to the engine and include the friction of all its parts and also of the belt. Following is a convenient method of arranging results:

TEST NO. 3, AT TWO-THIRDS LOAD.

Number.	volts.	Amperes.	Mean Effective Pressure.		Speed.
			Head End 1.	Head End 2.	
1	55.0	9.60	16.63	18.97	307
2	55.0	9.60	16.83	17.75	307
3	54.8	9.61	16.75	18 36	305
4	54.7	9.57	16.43	18.20	307
5	54.7	9.57	16.75	18.10	307
Total.....	274.2	47.95	83.39	91.38	1533
Average	54.84	9.59	16.678	18.276	306.6

Prime mover, Westinghouse simple engine acting through jack-shaft. Dynamo, 30-light brush arc machine.

Current corrected by curve of calibration, 9.632.

Watts, from volts corrected and multiplied by amperes, 1,098.50.

$$\frac{9.632 \times 1{,}098.50}{746} = 14.183 \text{ HP.}$$

Output equals 14.183.

Engine constant for both ends, .0003135.

Sum of M. E. Ps. 34.954.

34,954 x 306.6 x .0003135 = 33.954 HP.

Friction corrected for speed, 14.57.

Difference equals 19.02 HP input.

$$\text{Efficiency} = \frac{14.183}{19.024} = 74.55 \text{ per cent.}$$

An inaccuracy which is more or less unavoidable is certain to enter here. If the belt is thrown when the friction cards are taken, the power necessary to run it will be charged up to the losses of the dynamo; this is not quite fair, for the input of the dynamo should be measured at the pulley and the transmission devices connecting the engine with the dynamo are certainly no part of the latter machine. On the other hand, if the belt is left on and the load simply thrown off the dynamo, the mechanical losses of the latter are included in the friction card of the engine, which is also unfair. It has been suggested that two sets of friction cards could be taken, one with the belt on and the other with the belt off and that the difference would represent the belt friction. This is not true, for the difference would represent the belt friction plus the friction of the dynamo bearings and the air friction of the armature. The latter quantities are chargeable to the dynamo, but the belt friction is not, and there is no easy method of separating the two. The most satisfactory way is to lift the brushes off the machine and leave the belt on. If the machine is a good one, the bearing and air friction when running light will be but a fraction of a per cent. of the total load, and the method itself is open to greater inaccuracies.

Chief among these inaccuracies are the following: First, the errors of the indicator, which usually exceed 1 per cent. and may be much greater from unskillful manipulation. For instance, if the load is variable, and at the moment the observation is taken the fluctuation should occur, a large error might be involved. The card might register the cycle of events just before the governor acted and the readings of the electrical instruments would in all probability represent the output after that event occurred, for the observer would wait for the needles to steady themselves. Thus the efficiency might easily be 10 per cent. lower than it should be. This illustrates the necessity of a number of measurements and the average of them all.

Second, the friction taken at no load is by no means equal to the friction at full load; the error entailed by leaving the belt on when taking the friction card and thus adding to it the friction of the dynamo bearings partially balances the error just cited. It is customary to connect the friction card by assuming it proportional to the speed, but this is mere assumption. The friction is usually greater at heavy loads even though the speed is less.

Third, the belt slip measured in a linear direction is directly proportional to the power lost in heating the belt and the pulley and this power could not fairly be charged as having been received by the dynamo. It should be corrected for by determining the speed at which the pulley should run by the ratio of the radii, and also determining the speed at which it does run; dividing the latter by the former gives the percentage of the power as shown by the indicator cards that is chargeable to the dynamo as input.

If the efficiency is taken at various loads by a series of tests, an efficiency curve can be plotted from the results. It is best to take two sets of tests, one working from full load down, and the other working from no load up. All of the results should be plotted and a representative curve drawn.

The indicator method is not a very satisfactory one in many ways, but it has been used in default of a better and it is time-honored. Therefore, it has been given a place here.

INTERIOR WIRING.

CONDUIT WORK.

All first-class installations of interior wiring are now made according to some conduit system. An interior-conduit system consists of lines of tubing connecting the various outlets, and through this tubing the current-carrying wires are drawn. At the outlets and in some cases along the line are placed what are known as junction boxes to assist in installing the wire or fastening the switch or fixture. There are a number of conduit systems in use to-day, all of which have their advantages, and the principal ones are the following:

First, a system using tubes built up of insulating material. These tubes are stiff, and while good insulators, are unprotected from mechanical damage either during installation or subsequently. This was the first and the poorest of all conduit systems.

A second system which is somewhat related to the first consists of a conduit of insulating tube which is flexible, and this great advantage has made it find much favor in spite of the fact that it is open to objection as regards mechanical damage to almost as great an extent as the stiff insulating tube. Such conduits as these two are usually made of some absorbent material, such as paper or canvas, thoroughly soaked in an asphaltic compound, and for this reason they are undesirable for wiring in places where the temperature is liable to be high.

It was found that when these conduits were installed, especially along grooves

where moulding or wainscoting was tacked, that they were liable to be punctured by nails or crushed out of shape by pressure, thus hindering the drawing of wire or seriously injuring the insulation of the system after the wire was installed. This suggested a metal-armored condnit, which shortly afterward made its appearance. Among the first of these metal-armored conduits to appear was one which was covered with a thin brass armor. This made the conduit much stiffer, enabled it to bear a reasonable weight without crushing and was a great improvement, but it was not nail-proof. Nevertheless, in an installation of interior wiring there are not many places where a conduit needs to be nail-proof, and for this reason the brass-armored conduit found, and is still finding, great favor, and for certain classes of work is as good as anything else.

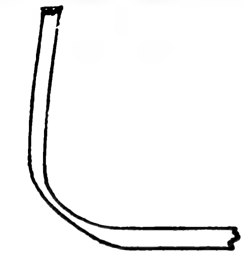


FIG. 1.—COLLAPSED TUBING.

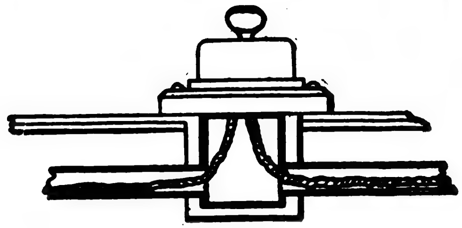


FIG. 2.—FLEXIBLE-TUBING JUNCTION BOX.

FIG. 3.—CONDUIT JUNCTION BOXES.

The desire for a conduit which was proof against the most severe damage has resulted in the production of an insulated gas pipe known as iron-armored conduit. It simply consists of an ordinary wrought-iron pipe lined with an insulating material and jointed together in the ordinary way by couplings. Aside from the fact that the threads of the couplings are straight and not tapering, and that the elbows are gentle sweeps instead of sharp turns, an iron-armored conduit installation much resembles a job of plumbing, although certain details which will be discussed later require careful attention.

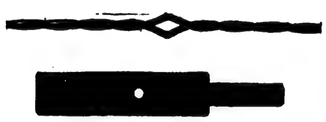


FIG. 4.—CLIPS FOR CONDUIT WORK.

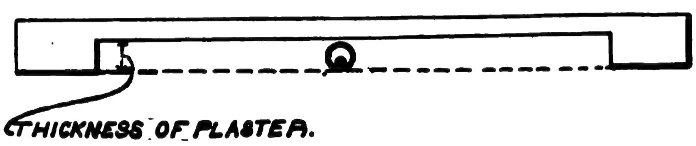


FIG. 5.—STRAIGHT-EDGE FOR CONDUIT WORK.

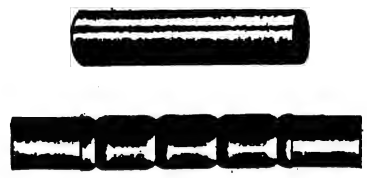


FIG. 6.—CONDUIT JOINT.

Beginning a detailed discussion of these systems, it may be stated that of the unarmored systems, the flexible tubing is the only one used to any great extent. The curves of this tubing are usually smooth and free from obstructions and the wire pulls easily into it. Care should be taken in making a curve that the bend is not too sharp, for if such is the case the tubing will flatten as shown in Fig. 1, thus making it difficult, if not impossible, to draw wire through it. It should be secured in place by soft sheet-metal clamps or twisted-wire clips such as are shown in Fig. 4. Staples should not be used, for the reason that even the most careful operator is liable to drive the staple in too tightly, thus crushing the tube, or by oversight, penetrate the tube by one of the legs of the staple.

Junction boxes are but little used in flexible tubing, for its flexibility enables it to be run from outlet to outlet and project through the wall several inches at either end. This is not easily possible with stiff tubing unless special elbows are used. Flexible tubing is used to a great extent in frame constructions where it can be drawn between and through the walls; it is an indispensable adjunct to concealed work, and it forms a most convenient auxiliary to the stiff-tubing systems in making difficult approaches or going round complicated bends.

Junction boxes may be conveniently made for flexible tubing as shown in Fig. 2. They are of wood and rectangular in shape and can be bored with any number of holes. The top is preferably a beveled slab of wood of the same finish as that used in the room where the box is installed, and on this is mounted the switch or fixture. This box may be used with either brass- or iron-armored conduit, but is inferior to the boxes which are provided for that purpose.

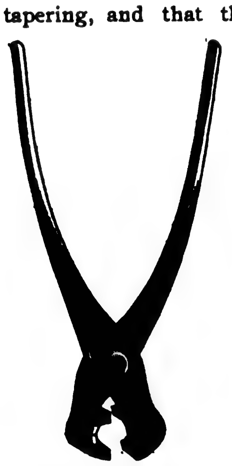


FIG. 7.—CONDUIT-JOINTING TOOL.

FIGS. 8 AND 9.—CONDUIT REAMERS.

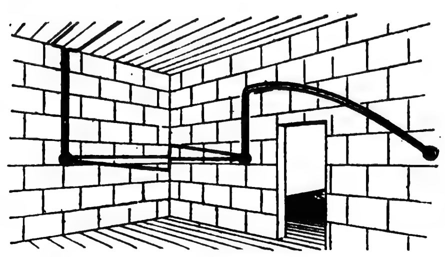


FIG. 10.—THE USE OF THE DOUBLE ELBOW.

FIG. 11.—SPECIAL CORNER BOX.

The brass-armored conduit system is provided with junction boxes of every type, examples of which are shown in Fig. 3. This system is largely used when the conduits are to be embedded in plaster. The conduits are run on the surface of the tiling and secured by the clips provided for such work to little wooden plugs driven in between the tiles. Care must be taken that every part of the conduit is the proper distance from the finished surface of the plaster. A straight-edge shown in Fig. 5, will be useful in determining whether or not any of the tubing bulges out too far. There is liable to be considerable warfare between the wiring contractor and the plasterer, for the latter is inclined to put on thin plaster.

Flexible tubing should be run without joints, but this is not possible with the brass-armored system. A special coupler shown in Fig. 6 is used for this purpose. The ends of the conduit are carefully prepared and the coupler is crimped in place by a special tool shown in Fig. 7. This joint should be made additionally tight by the use of P. & B. paint. Soldering is sometimes used, and while it makes a superior job, is somewhat more tedious. In this process the ends to be united should be moistened with acid and tinned in a soldering-pot and after having been crimped together they should be sweated with a blow-torch. The reamers shown in Figs. 8 and 9 are much to be recommended in preparing the ends of the tube for joints.

Elbows should be carefully inspected before being installed by pushing a bit of fishing wire through them. There is liable to be slight obstructions in these elbows that can be easily removed, but which would be serious if it were attempted to pull wire through them after they are in place. Three elbows are about all that can be interposed in a run of wire, and four make a very difficult pull indeed.

A difficulty which is often experienced in making the turn from ceiling to wall without involving a sharp corner is conveniently avoided by the use of two elbows as shown

in Fig. 10. By this device the tubing need not appear above the surface of the plaster at the bend. Long bends can be made in the brass-armored tubing and if they do not crease the armor, they are admissible so long as the work is to be concealed. Open brass-armored conduit work must be installed with the same regard to symmetry as open cleat-work.

Fig. 11 shows a special box that is very convenient in going around a corner, and at the same time giving a point of vantage in drawing the wire. It may be completely sunk below the plaster level if this should be necessary.

Fig. 12 shows a special elbow, already referred to, and one that is indispensable where it is found necessary to install a system without junction boxes. It is also illustrative of the method of wiring conduit to terra-cotta tiling. In cases where the conduit is subsequently to be bound by plaster, the fastenings are merely a temporary device, except at the outlets, where considerable pulling and straining is necessary to draw in the wire.

Fig. 13 shows a special junction box for a combination chandelier. The U-shaped incision is intended to surround the gas pipe after the manner of the well known horseshoe cut-out.

It may be well to call attention to the flexibility of the junction-box system. Any of the circular junction boxes shown will contain a cut-out or switch, single or double pole; a crow-foot that will support either a side bracket or chandelier may be screwed to the bottom of such a junction box, if desired.

The various covers that may be fitted to such junction boxes increase the scope of the latter in many ways. If the box is not to appear after the wire has been drawn, a flat cover, which can be hidden behind the plaster, can be put on. If its appearance is necessary an ornamental spun cover can be substituted, and if desired, this may carry a bushing through which a fixture-cord can be drawn, to be attached to a portable or desk lamp. The cover may carry a screw nipple on which a light side bracket can be mounted. If it is not desired to use an outlet, the wire ends can be taped and thrust within the junction box, which can then be neatly covered. In this way the ordinary unsightly wire ends of an unused outlet can be avoided, and at the same time insure that the unused terminals will not be tampered with and short-circuited.

FIG. 12.—SPECIAL ELBOW.

FIG. 13.—CHANDELIER JUNCTION BOX.

SUGGESTIONS FOR ELECTRIC RAILWAY PRACTICE.

CAR OPERATION.

BY WALTER MUNROE.

The manner in which different motormen handle the speed-controlling mechanism of street cars will be found to vary widely. An observant person or one connected with a railway may note this, and if he eadeavors to go into the subject at all, speedily finds himself trying to get at the reason for this state of affairs.

Now, in performing a piece of work there are at least two ways of going about it—a right way and a wrong way—and the question naturally arises, which is the right way? for that is the method desired.

For instance, take the case of a car equipped with G. E. K2 controllers. One motorman in starting the car will bring the controller handle round to the first point with a snap, allow the car to start easily and gain speed, then snap the handle to the second point and so on, allowing the car to accelerate easily and yet briskly until it reaches the required speed.

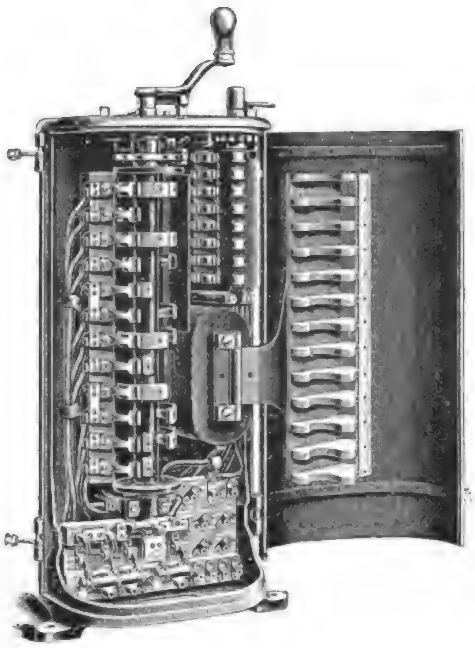


FIG. 1.—K2 CONTROLLER.

Let us take another case. This motorman, we will assume, is behind time or making his last trip. When he hears "two bells," he immediately, without stopping at intermediate points, rushes the controller handle to the second or it may be, the third notch. This starts the car with a jump, puts a severe strain on the motors, and causes more or less discomfort to the passengers. Now, this method is one much too often used and should be carefully avoided.

The objections to this method are as follows: For various fundamental reasons, the modern railway motor is of quite low resistance. The total resistance of the armature and field together, of a certain well known type being a little over one ohm. Even with two motors in series it would not be safe to connect them directly to 500-volt mains because of the excessive current that would flow. (In the K2 controller the start is made with the two motors in series with an external resistance.) It would cause them to start with a suddenness that would endanger the car, to say nothing of the passengers. The starting resistance is put in in order to insure a smooth start, and does, incidentally, keep the current within reasonable limits.

To give a practical illustration, it may be observed that when a lighted car is at the far end of a line or at a distance from a feeder, a very sure result of these sudden starts, is the extreme dimming of the lamps. This is caused by the lowering of the line voltage, for the supplying of this excessive starting current, causes a considerable "drop in line."

Let C = current flowing in a motor; E = line voltage; E' = back E. M. F., and R = total resistance between line and ground.

Then $C = \frac{E - E'}{R}$

Now, taking the case of one motor to illustrate. If the motor were connected directly to 500-volt mains, the car would prevent the motor from speeding up rapidly, and therefore E' does not have time to attain a value large enough to keep C within reasonable limits. Let us assume $E' = 100$ volts, then

$$C = \frac{E - E'}{R} = \frac{500 - 100}{1} = 400 \text{ amperes.}$$

With two motors in series it would be 200 amperes, either being a very objectionable state of affairs. This, of course, is an extreme case, but it may be approached very nearly, in practice.

We venture to predict that the electrician of many a road would receive a surprise from an ammeter placed in the main circuit of the car (unknown to the motorman) on one of there hurry trips, and it is barely possible, also, that the motorman would receive a surprise from the electrician. In general, however, we think it is done through ignorance, or, in an endeavor to make up time. Let us see what this excessive starting current means.

The higher values of the energy used in propelling street cars, where the stops are at all frequent, are absorbed in starting and accelerating them. Hence the current taken in starting is greatly in excess of that used when the car gets up to speed. It is thus very evident, that every effort should be made to cause the motorman to handle the controller in a proper manner. Otherwise it means so much extra load on the power plant.

The load on a railway power station is bound to be a fluctuating one, anyway, and the units ought to be handled so that when carrying the mean load they are at their most economical running point. Now these abnormal draughts of current make peaks in the load curve, and if much of it is allowed, it means a serious increase in the mean load of the station.

It has been shown, by reliable tests, that the running time is not greatly decreased by these forced starts. It may be assumed to be under 3 per cent. for distances up to 5 miles. If the stops are many there is little gain, for if the car is properly handled it will be allowed to "drift" to the next stopping place after reaching a speed high enough, while if the stops are few, the time used in starting is so small, compared to the total running time, that the difference be-

tween forced and normal starts is very slight. Hence, it would seem that ordinarily there is no excuse for this method of operating the cars.

During the same tests, comparative runs were made with the same car and approximately the same conditions, except that in one case a regular motorman operated the car, while in the other the electrician's assistant handled the controller. This motorman was, if anything, rather above the average ability of the men, and ran the car in his usual way. The electrician's assistant used every effort to keep the energy consumption down and yet maintain schedule time. It was found that for the round trip there was a difference of 20 per cent. in the watt-hours in favor of the assistant. It seems perfectly safe to assume that one-half this value, or 10 per cent., might be saved for each motorman in every-day practice.

There is another method of handling the controller that results in the consumption of an excessive current. It may occur on those cars that get their last increase in speed when the motors are in series or in parallel, by weakening the field. One way of doing

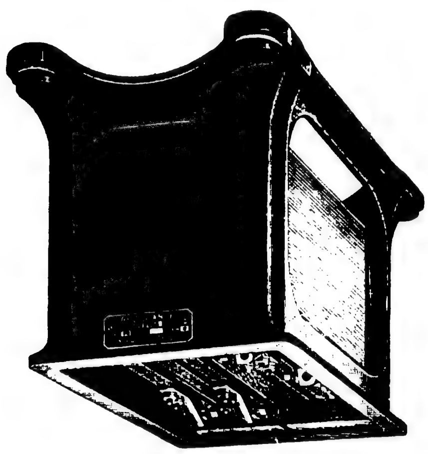


FIG. 2.—CONTROLLER RESISTANCE.

this is to shunt part of the current in the field through a resistance box.

Another method is to cut out part of the field turns. When the field coils are shunted in this way, the back E. M. F. is decreased, since it is directly proportional to the field strength. Now, it was shown above that a decrease in the back E. M. F. means an increase in the current flowing through the armature, and this is exactly what occurs.

We will assume that the car is running at a uniform speed and that we suddenly shunt the fields. Then the fields are weakened, and the armature current is strengthened momentarily. This increase in armature current increases the turning moment on the car axle, and the car speeds up, cutting down the current until the energy consumed is just sufficient to keep the car in uniform motion. Now this is all very well on a level or anywhere that the car can easily attain a fairly high speed, but when it is done on a curve or a heavy grade where the car cannot easily attain a reasonable speed, there results, as before, an excessive drain of current from the power station.

It cannot be too strongly impressed on the motormen that they must not use the points that weaken the field under the conditions above given. On the K 2 controller, these points are the *fifth* and last; on the K the *fourth* and last. The proper points to use are the ones just preceding these, as we then have the full field of the motor acting, and all external resistance cut out.

On a road having many heavy grades, it may happen that the motors, while running, get much hotter than seems advisable. This is especially likely to happen when there are a number of heavily laden cars running together on some special occasion. At such a time as this, when it is of the utmost importance that the service be regular and adequate to carry the crowds, it too often happens that armatures burn out.

We may assume the final cause of this to be excessive and prolonged overload (current very large). This, of course, means a more or less prolonged delay, and to a certain extent, loss of confidence in the road on the part of the public. Now what is the cause of this and how can it be remedied?

It is, of course, perfectly well understood, that it takes more energy ($E\ C$) to propel a car up a hill than to run it on a level, at a given speed. If we assume that the voltage remains constant, the current would have to increase in exact proportion to the necessary increase in the energy. As a matter of fact, the current used is more than the above assumption would give, on account of the drop in line referred to above.

That is to say, let energy consumed on a level $= E\ C$, and that on a hill $= E'\ C'$, and suppose $E'\ C' = 2E\ C$ and $E = E'$; then $C' = 2C$. But if E' is less than E, then C' must be increased enough to bring $E'\ C' = 2(E\ C)$. Again, the heating of a motor is proportional to $C^2 Rt$, where $C =$ current used, $R =$ resistance in ohms and $t =$ time in seconds; so that, in a given time with the current doubled, we have the heating effect quadrupled. As we have said, it requires a certain amount of energy to climb that hill. Suppose now we increase the voltage at that point, what is the result? Since the speed of a motor is proportional to the voltage across its terminals, it follows that the car will ascend the hill more rapidly and thus cut the current down. This, of course, reduces the heating of the motors.

There are at least two methods of increasing the voltage at a given point. You may increase the line voltage as a whole, or a feeder may be run to this particular point, lessening the "drop in line."

When a temporary relief only is needed the raising of the line voltage would be most convenient, but for permanent service a special feeder is the thing, it being much more economical for prolonged use. It is, of course, clear that it would not be advisable to run this extra feeder unless it was shown conclusively that the relief afforded or the speed gained would be sufficient to compensate for the cost of putting it up. If there is already a feeder in the immediate vicinity, you might safely raise the voltage on this feeder alone. The writer has in mind a certain railway that uses a booster to raise the voltage at the end of one of its distant lines. This is done when the load on this particular feeder exceeds a certain amount. It has been found that at about this load, the voltage at the end is insufficient to run the cars at proper speed.

This booster is a T.-H. D 62 machine, and has a special winding of heavy cable on its field spools. The field and armature are in series. The field is so wound that when 100 amperes are flowing through the machine, it raises the voltage by 100. Ordinarily this particular feeder is connected through suitable switches, with the positive bus bar of the station.

By means of other switches, the booster may be cut in to the feeder circuit at any time.

It is quite probable that on every road there are places where a car consumes an excessive amount of energy. In a good many cases this can be remedied. These bad places may be curves of extremely short radius, an excessive grade, a curve on a grade, etc.

A very good method of finding such places is to take a car, put an ammeter in the main circuit, a voltmeter across the line and obtain the speed. The speed need be obtained only roughly. Then with this car and several observers, make trips over the entire road, taking readings on the instruments. In this way the entire road may be mapped out, and valuable information obtained for future use. From the data thus obtained the electrician can tell at a glance what the current consumption was at any part of the road, and thus determine what changes are necessary.

In one series of tests made by the writer this method was used, readings being taken every ten seconds during the entire trip.

In a test of the nature above mentioned it will not be necessary to take such frequent readings, except where the load variation during a particular time is wanted.

Another method would be to connect a wattmeter in the car circuit. This would be used more where the watt-hours per trip or per car-mile were wanted.

In conclusion, it may be said that the road which provides a careful method of training and looking after its motormen, and has a methodical system of inspecting its entire apparatus, will find that it has saved a considerable amount in its operating expenses. Try it and see for yourself.

THE LEVER SAFETY VALVE.

BY C. A. COLLETT, V. P., N. A. S. E.

What rule do boiler manufacturers follow in determining the proper area for a common lever safety valve orifice? A well known mechanical engineer, in replying to this question, said:

"So far as my observation and information extend, the rule most generally followed by boiler makers, in such cases, is the rule of thumb."

To the engineer having any regard for the safety of life, limb and property, this cannot be otherwise than a most unsatisfactory rule and the object of this article is to ascertain, as far as possible, to what extent the several rules laid down by authors harmonize, and to enable the inquisitive engineer to decide, by the application of the rules, whether his safety valve is of ample capacity to relieve the boiler of an overproduction of steam, or not.

Question No. 21, of the series of questions propounded by the N. A. S. E. Educational Committee, runs as follows:

"If a boiler evaporates 3000 lbs. of water per hour, what should be the size of the safety valve? (Pop or lever.)

It will be noticed that the pressure under which the water is evaporated is ignored in this question. Perhaps this is intentional, and perhaps an oversight. What the committee means by "size" is probably the area of the safety-valve orifice.

Chas. Haswell is generally considered good authority by engineers; in fact, very few engineers, with or without M. E. affixed to their names, are prepared to dispute the accuracy of any proposition, formula or rule laid down by this eminent engineer. Mr. Haswell, in his Pocket Book, 51st edition, page 746, says: "Up to a pressure of 100 lbs. per square inch, the area of safety valve in square inches, equals the product of weight of water evaporated in pounds per hour by .006."

This rule is certainly clear enough to suit the most fastidious, and its simplicity is admirable, and were it not for the fact that it is inapplicable to pressures exceeding 100 lbs. per square inch, we should stop right here and exclaim, Eureka!

But, since pressures considerably higher than 100 lbs. are quite common, if not fast becoming the rule nowadays, we cannot rest content with Mr. Haswell's rule, but must needs cast about for something more in harmony with up-to-date practice. But, before proceeding any farther, we will apply the rule before us to question 21, and note the result, and in doing so we have: $3000 \times .006 = 18$ sq. ins. as the area of a lever safety-valve orifice. This would give a diameter of about 4.78 ins.

Now, according to the Centennial rule, a boiler evaporating 3000 lbs. of water per hour would be rated at about 100 HP. The writer can locate half a dozen 100-HP boilers having safety valves much less than 4.78 ins. in diameter, one of them having a safety valve with an orifice only 3 ins. in diameter, but these are presumably rule-of-thumb safety valves.

The U. S. rule for finding the area of orifice of a lever safety valve is: Allow 1 sq. in. of valve area for every 2 sq. ft. of grate area. Now, in order to favor Haswell's rule as far as possible, we will give our 100-HP boiler a diameter of 72 ins. and carry 80 lbs. of steam. With a 6-ft. grate bar, which by the way is 6 ins. longer than it ought to be, we would have 36 sq. ft. of grate surface, and according to the U. S. rule, we would also have 18 sq. ins. of valve area, which agrees precisely with Haswell's rule.

But, suppose our 100-HP boiler were 60 ins. diameter by 16 ft. long, our grate area then would most likely be about 28 sq. ft., giving us 14 sq. ins. of valve area, which does not agree with Haswell's rule. As a matter of fact, this boiler has a safety valve only 3½ ins. in diameter, giving an area less than 10 sq. ins., which is far short of the requirements of the U. S. rule.

We will now proceed upon another tack. Evaporating 3000 lbs. of water per hour is equivalent to evaporating .833 + lbs. per second, or ⅚ lb. per second.

Now, it is understood that no matter how hard our boiler may be fired and forced, no matter what kind of fuel we may use, and notwithstanding all our exertions to promote a more rapid evaporation, ⅚ lb. of steam per second is absolutely all that we can get at any pressure, and our safety valve must be of such size as to allow the escape of this ⅚ lb. of steam as fast as it is generated. Now, it is well known that the velocity of steam escaping from a boiler increases with the increase of pressure, and that the greater the velocity, the less area of orifice is required to permit the passage of a given weight or volume of steam.

To illustrate: If we have a cubic foot of steam moving with a velocity of 1 ft. in 1 second of time we must provide an orifice having an area of 1 sq. ft. for it to pass through. But, if this same cubic foot of steam moves with a velocity of 144 ft. per second, an orifice having an area of 1 sq. in. will be sufficient to allow of its passage. But, it certainly will require a greater force, a higher pressure in the latter case than in the former, because if we do not increase the force which moves the cubic foot of steam 1 ft. in 1 second, it will take 144 seconds or 2 minutes and 24 seconds to move it 144 ft.

Another authority, whom we consider thoroughly reliable, gives the following:

"The area necessary to discharge the steam as fast as it is made will be found by multiplying the maximum weight of steam that can be generated per second by 70, and dividing the product by the absolute pressure." The area here referred to is the area produced by the lift of the valve. And right here it is well to remark, that no matter what the area of valve orifice may be, it is the area produced by the lift of the valve that determines the possibility of relieving the boiler of steam as fast as it is generated.

Now, in applying this rule to question 21, we will assume a gauge pressure of 85 lbs. or 100 lbs. absolute. This is a good working pressure and is quite common.

We will first find the efflux velocity of steam at this pressure thus:

$$\frac{270}{62.425} = 4.325 \text{ cu. ft.}$$

Then, $4.325 \times 100 = 432.5$ cu. ft.,

and, $432.5 \times 144 = 62,280$ cu. ins.,

and $\sqrt{62,280} = 249.55$.

Then, $249.55 \times 3.6 = 898.38$ lin. ft. per second, the efflux velocity of the steam.

Now let us apply the rule.

Our evaporation is .833 lbs. per second. And $.833 \times 70 = 58.31$. And $58.31 \div 100 = .5831$ sq. in., the area required at 100 lbs. absolute pressure. As we have seen, the diameter of the orifice is 4.78 ins. Then, $4.78 \times 3.1416 = 15.016848$ ins., the circumference of valve orifice.

Now, in order to get the lift of the valve we proceed in this manner: $.5831 \div 15.016848 = .0388$ in. or very nearly $\frac{1}{25}$ in., or a little more than $\frac{1}{25}$ in. Now we can simmer the whole thing down to this:

A round hole, having an area of nearly ⅝ sq. in., or an oblong square opening, $\frac{1}{25}$ in. wide, nearly, and about 15 ins. long—having the same area—will be sufficient to relieve our 100-HP boiler of steam, at 85 lbs. gauge pressure, as fast as the boiler can generate it, and a lever safety valve, with an orifice having an area of 18 sq. ins., or a pop valve, having an area of 12 sq. ins., or 66⅔ per cent. of the former, will be ample to meet the requirement.

Now, let us find with what velocity .833 lb. of steam, at 100 lbs. of absolute pressure, flowing through an orifice of .5831 sq. in. area, must travel. The weight of 1 cu. ft. of steam at 100 lbs. absolute pressure is .2307 lb. Then by proportion we get the number of cu. ft. which .833 lb. of steam will make at this pressure, thus:

$.2307 : .833 :: 1 : 3.61$. Then, $3.61 \times 1728 = 6238.08$ cu. ins. And, $6238.08 \div .5831 = 10698$ lin. ins., and, $10698 \div 12 = 858$ ft. per second velocity of the steam. We figured the efflux velocity at 898.38 ft. per second, and $898.38 - 858 = 40.38$ ft. inside the limit, which will permit of a less area of opening than .5831 sq. in., or a less lift than $\frac{1}{25}$ in.

Now, whether a boiler pressure of 85 lbs. will cause this lift of $\frac{1}{25}$ in. or not, depends upon the construction of the lever safety valve; that is, its design, workmanship and materials. If properly designed and accurately constructed, so as to lessen its inertia and reduce the friction at the fulcrum to a minimum, we may reasonably expect it to do so very nearly, but if it is made in the rough, slip-shod manner in which safety valves of this style are usually turned out, it can scarcely be expected to do so, and, in fact, will not do so. If lever safety valves were susceptible of such nice adjustment as pop valves, and were as positive in their action, we should have no doubt on this score. But they are not, and in the nature of things, cannot be made so.

Hence, in the writer's opinion, the use of lever safety valves on steam boilers—at least, all those carrying high steam pressures should be prohibited by law, and the use of pop valves made compulsory under a heavy penalty; and while we say this, we also say, that we have no interest in the manufacture or sale of pop valves, either directly or indirectly, near or remote, present or prospective.

It is safe to assert that a very large proportion of the common lever safety valves, now in use, are nothing better than "dummies," and serve the purpose of enabling the builder of a boiler to comply with the specifications without any regard to their worth or value as catastrophe-preventers. A better and more appropriate name for such safety valves would be, "infernal machine," for such we have found them to be in several instances.

Engineers should bear this important fact in mind, that with a common lever safety valve, the higher the pressure of steam the less will the valve rise off its seat, when it should act the reverse of this, and rise higher with the higher pressure. It is true that steam at a higher pressure has a greater efflux velocity per second, and as a consequence requires a smaller aperature for the escape of a given volume of steam per second, but this fact should not militate against the necessity of affording ample space for the escape of rapidly generating steam of a high tension, into a higher tension, and this is precisely what the pop valve will do if in good working order; and right here it is pertinent to remark that an engineer should know at all times, whether his safety valve is in good working order or

not, be it a lever or a pop valve, and take no chances, nor rest satisfied that it is so, because it was so yesterday or the day before, for there is nothing certain in this world, but death and taxation.

Prof. Burg made a great many experiments with safety valves both lever and pop of various shades and designs. He found that, with a common lever valve of best workmanship, and with its seat beveled at an angle of 45 degs., and with a boiler pressure of 45 lbs., the lift of a valve 4 ins. in diameter was but $\frac{1}{84}$ in. while at a boiler pressure of 90 lbs., it was but $\frac{1}{168}$ in., or less than one-half the lift at 45 lbs., thus presenting us with a rank inconsistency which could never find lodgment in a pop valve from the very nature of its construction. While prosecuting his researches the professor found also, that the area of opening produced by the lift of a 3 in. valve with its seat beveled at an angle of 45 degs. was but .56 sq. in. Now, when we consider that the area of a 3-in. valve is 7.0686 sq. ins., we are struck with the amazing disproportion between the two areas. A 3-in. pop valve would afford an area of opening, due to the lift of the valve, more than three times as great as that given above, which speaks volumes in its favor.

With the passing of a great many crude, primitive and ill-adapted engineering devices and appurtenances, we hope to witness ere long the passing of the common lever safety valve, and its consignment to the scrap heap where it properly belongs, and where it should even now be quietly reposing.

DISTURBANCES ON TELEPHONE LINES.

In a previous article the subject of telephone disturbances was treated and in this some of the points there brought forward will be considered more in detail.

If the cause of electromagnetic disturbances on telephone lines is clearly understood, one will have no difficulty in applying the principles involved to different cases that come up, however divergent they may appear to be. We shall, therefore, begin with the elements of electromagnetic induction so far as they relate to the subject under consideration.

It is known that when a current passes through a conductor, the medium surrounding that conductor is thereby influenced. Faraday, in order to have something tangible to guide him in his investigations, conceived the idea of lines of force and imagined that when a current passes through a conductor, lines of force are set up about it, the lines being concentric with the conductor. If these lines of force cut any conductor, an E. M. F. is set up in it, of a value depending upon the rate of cutting and length of conductor cut.

Fig. 1 represents a conductor surrounded by lines of force, which are represented as being more numerous near the conductor than at a distance away. The rate at which the lines fall off is greater, however, than indicated by the sketch, the number diminishing rapidly as the distance from the wire increases.

If the current is a continuous one, the lines of force remain after once being set up, the number neither decreasing nor increasing. The number of such lines surrounding a conductor is always proportional to the current passing through, so that if the current is alternating, the number of lines present varies with the strength of the current; they decrease from a maximum number, entirely disappear and then appear again in a reversed direction, gaining strength until the current reaches the maximum negative value, when the cycle is repeated in reverse order, and so on.

If, now, there is any conductor in the neighborhood of a wire carrying an alternating or telephonic or any current varying in value, the lines of force sent out by the latter will cut the conductor alternately in opposite directions. This will set up an E. M. F. in the conductor cut in precisely the same manner that an E. M. F. is set up in the conductor of dynamos. In each case the conductor is cut by lines of force, and it makes no difference if, in the case of a dynamo, stationary lines are cut by the moving conductor, or in the other case, that a stationary conductor is cut by moving lines.

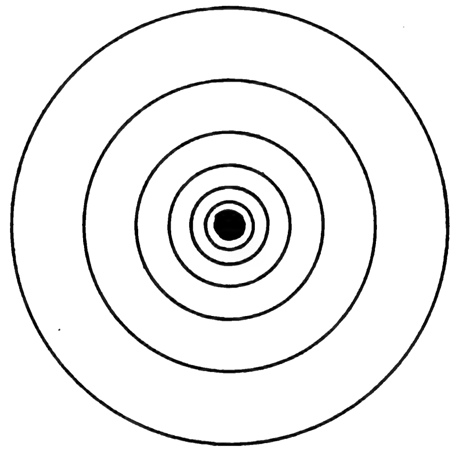


FIG. 1.—LINES OF FORCE ABOUT CONDUCTOR.

Suppose, now, we have a telephone line running parallel with another line carrying an alternating current or a line in which the current fluctuates, such as some forms of arc currents. First, we will consider that the telephone line has a closed metallic circuit; then, as lines of force from the disturbing line enter and leave the telephone circuit, an inductive E. M. F. will be set up, which will affect the action of the telephone receiver. The amount of this inductive E. M. F. will depend upon several factors. The nearer the line is to the disturbing source, of course, the larger the number of lines that will enter and leave it, and, therefore, the larger the inductive E. M. F. It is evident also that the longer the distance that the lines run parallel with each other, the greater will be the inductive E. M. F., because the greater will be the total number of lines that will enter the loop of the telephone circuit. It is also plain that the closer the two telephone wires are to each other, the less will be the area of the loop into which the lines of force can enter, and, therefore, the less the inductive E. M. F.

Finally, the closer together the two wires of the disturbing circuit, the less will be the inductive disturbance. This latter point will be rendered plain by referring to Fig. 2, where M N is the disturbing circuit. The lines of force which go out from one wire are in reverse direction to the lines from the other wire. The wire N being nearer to the telephone circuit, CD, the number of lines from it which will cut in and out of that circuit, will be greater than the number of lines from the wire M, on account of the greater distance away of the latter conductor. Therefore, although some of the lines of N will be neutralized by lines from M, the effect of N will still predominate. The nearer together M and N are brought, the less will be the difference between the lines due to A and the lines due to B; if the two conductors were concentric, the lines of one would, in fact, entirely neutralize the lines of the other, and there would be no influence on an exterior circuit.

It will thus be seen that where control can be exercised over a disturbing source, its two conductors should be required to be placed as closely as possible together and as far as possible from the telephone line, or be transposed at intervals. It is very rare, however, that there is any control over a disturbing source, and it is consequently necessary for the telephone lines, where possible, to be so installed that they are non-inductive with respect to exterior circuits.

This may be done by transposing the two lines of a metallic circuit as shown in Fig. 2. In this case the inductive E. M. Fs. in the sections of wire nearest to the disturbing source will be in one direction and in an opposite direction in the sections furthest from the source. By transposing the wires as shown, it will be seen that the E. M. Fs. induced in any one of the wires will be alternately in opposite direction and thus will neutralize each other. This, of course, is only rigorously true when the disturbing and telephone lines are exactly parallel to each other.

If the two circuits are everywhere parallel and the current in the disturbing line always has the same value, only a single transposition would be necessary, however long the line. If the lines vary from parallelism, there should be one or more transpositions between the points where such variation begins and ends. As, however, another advantage of transposed telephone lines is to obviate disturbance from magnetic storms,

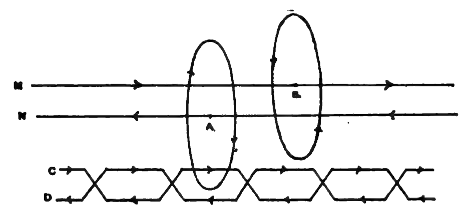


FIG. 2.—OPPOSING LINES OF FORCE.

during which lines of the earth's field cut in and out of a loop in the same manner as above described, transpositions should be made at short intervals regardless of the parallelism of the circuits.

As stated before, in the case of a metallic circuit the actual area in which the disturbance from external cause has its effect, is that between the two conductors of the telephone circuit. In the case of a grounded circuit, however, the area affected extends beneath the surface of the ground—the condition being as if there were a second conductor as far beneath the surface as the

actual conductor is above it. From this it is evident why disturbances are so much greater on grounded lines.

If, however, it were possible to practically meet certain conditions, a grounded line could be rendered free of disturbances from an external metallic circuit carrying a variable current, though not from a grounded one.

Suppose the conductor of a grounded circuit is placed midway between the two conductors of an alternating-current circuit; then all of the lines entering the loop of the grounded circuit from one wire will be nullified by lines entering the same loop in an opposite direction from the other wire. This requires almost mathematical accuracy in placing the telephone wire midway, as it will be in an intense field and the slightest variation from a balance would result in setting up an inductive E. M. F.

It is not necessary, however, for the wires to be, as in the above case, in the same plane with the two wires of the exterior circuit. If the telephone wire is placed any distance above or below these wires and everywhere equally distant from them, the lines of force would equally neutralize each other. This will be rendered plain by drawing a diagram showing relatively the lines of force proceeding from the two wires of the exterior circuit.

Still a third case presents itself. If the grounded wire were transposed at intervals and always placed in the same relative position with one or the other wire of the disturbing circuit, then if the strength of the current in that circuit did not change, the lines tending to produce a disturbing effect in one transposition would be neutralized by a similar number of lines in the next transposition—the length of the transpositions being the same. Suppose that two adjacent transpositions are designated by *A* and *B*. Then, while in the case of *A* the lines from one of the disturbing wires will predominate, in the transposition *B*, the lines from the other will predominate, and if the lengths are the same there will be a balance and no inductive effect. It is understood, of course, that the telephone wire should have the same relative position with reference to one or the other disturbing wire; that is, if it is a certain distance vertically below a wire on one transposition, it should be exactly the same distance vertically below the other wire on the next transposition. If there is any change in this respect, there cannot be any balance, for the telephone loop will receive more lines from one wire of the circuit than from the other.

All that precedes refers to electromagnetic induction alone. Disturbances from electrostatic induction are different in principle, and are less frequently met with on ordinary telephonic lines.

AN ELECTRIC BATTERY FOR FIRING CANNON.

BY JAMES F. HOBART, M.E.

With a little ingenuity and a few tools, a good many instructive electrical experiments can be performed. The firing of a cannon by electricity is easy, and the cost of apparatus is light. Procure several yards of No. 14 or 16 insulated copper wire; 100 arc-light carbons; two pieces of zinc 10 ins. square; two water-tight kegs or jars at least 6 ins. in diameter and 10 ins. deep; five pounds of bichromate of potash, and one pound of commercial sulphuric acid.

Wooden tubs or pails will answer for the containing vessels, but two neat glass jars make a much more desirable outfit, and may be bought for about thirty cents each. Four or five yards of bare copper wire will be needed, also a few inches of the fine German silver wire that may be unwound from the "G" string of a violin.

Cut out two pieces of board as round as possible, and make them 4 ins. in diameter. Select a round wooden or tin dish that is about 5 ins. in diameter, put a wooden circle inside, then set up carbons all around the wooden circle. Do not put in so many that they will not all bear against the wood circle, then bind all the carbons with a string, so they are held tightly to the wood. Take care that the carbons all touch each other so that the current may be able to travel from one to the other. After the carbons have been temporarily secured by a string, slip the latter one side slightly and wind tightly and firmly with the bare copper wire. The object is to practically bind forty-five or fifty of the carbons into as solid a circle as possible.

In enough hot water to fill one of the vessels or jars, dissolve all the bichromate of potash that the water will take up. Mix with this solution one-tenth its weight of sulphuric acid. After placing one of the circular carbon shapes in each of the cells, pour in enough of the solution to fill the jars three-quarters full. The wood-filled end of the carbons should be at the bottom, and a rubber band had better be slipped around the top of the carbons to hold them together. A copper wire slightly twisted around the top of one of the carbons, serves to connect the battery with the cannon.

The carbon forms one element of a battery cell, and if the 10-in. sheet of zinc be rolled up into a tube and inserted in the carbon circle, a cell of the battery will be complete. A piece of copper wire should be fastened to the zinc to serve as the other conducting wire. Two rubber bands should be placed around each zinc cylinder, near either end, to prevent any possibility of its coming in contact with the carbons. Two cells of battery should be prepared as above, and connected together by fastening a piece of wire to the carbon of one and to the zinc of the other cell, then carrying wires from the other zinc and carbon elements to the cannon.

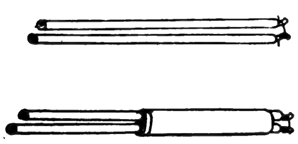
The insulated wire should be used to make connections, and the powder in the cannon is fired by attaching to the ends of the conducting wires a short bit of the violin string wire. Fig. 1 shows how to connect the fine wire. There must be only a very short length of fine wire between the conductors —say one-eighth or one-twelfth of an inch, or our battery will be unable to heat it hot enough to ignite the powder. It is perhaps unnecessary to state that the small bit of wire must be thrust into the vent of the cannon, and fine powder placed around it before the battery is connected to both of the wires preliminary to firing the cannon. One wire may be connected and do no harm. The other wire should only make contact at the instant of firing, and a single second will do the work.

It is, however, very necessary that the wires that go into the cannon be thoroughly separated or insulated from each other and the metal of the cannon, by winding between or around the wires some thin oiled or paraffined paper. Fig 2 shows how the fuse looks when ready to be put into the vent of the cannon.

Fig. 3 shows a longitudinal section of part of the cannon, with firing fuse in place and the battery cells all connected as in the act of firing. An ordinary telegraph key is usually used for firing, being connected as shown. Fig. 4 shows the carbon circle; Fig. 5 the zinc, and Fig. 6 represents two complete cells of bichromate battery after they have been constructed as here described, and set up ready for use.

Electrically considered, the battery described would have an electromotive force of about two volts, and a resistance of one-tenth ohm per cell. As there are two cells, the battery would have an electromotive force of four volts, which, being divided by the resistance of both cells—two-tenths of an ohm —would give a current of $4 \div .2 = 20$ amperes, causing the little piece of wire ⅛ in. long to become white hot almost instantly.

One cell of battery will fire the cannon when the connecting wires are short, and when the battery is at its full strength. It is, however, better to avoid all the "ifs" that may cause failure, and make success sure by plenty of battery power. When the battery is not in use, the zinc should be removed from the solution in order that the battery may not waste away when not actually needed. The bichromate solution is a deadly poison when taken internally, and should not be left in the way of children or people who do not know its nature.



FIGS. 1 AND 2.—FIRING FUSE.

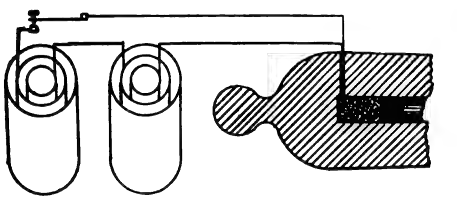
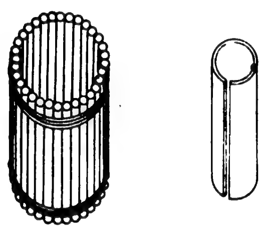


FIG. 3.—CONNECTIONS FOR FIRING.



FIGS. 4 AND 5.—BATTERY CARBON AND ZINC.

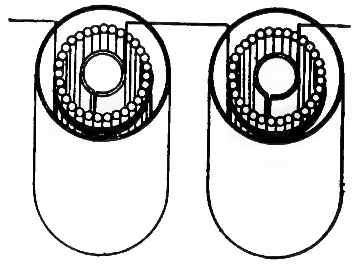


FIG. 6.—BATTERY COMPLETE.

A BIOGRAPHICAL HISTORY OF ELECTRICITY.

When Arago in 1824 noted that if a non-magnetic conducting body is oscillated in close proximity to a magnet, a disturbing influence is exerted on the former, he little knew what great significance was contained in the observation. Nor a year later when he devised the "Arago disk" arrangement, did he know that it illustrated beautifully the principles of electromagnetic induction, whose discovery in 1831 was to immortalize the name of Faraday.

Michael Faraday (1791-1867), the son of a poor mechanic, had few advantages of education. After several years at public school, he was, at the age of thirteen, apprenticed to a bookseller. After acting as an errand boy for a year, his employer permitted him, without the payment of a premium, to enter the bindery to learn the trade of book-binder. His term of apprenticeship having expired in 1812, he worked as a journeyman for a few months when, fortunately, he procured from Sir Humphrey Davy a situation in the Royal Institution, his duties being to assist the lecturers and keep the apparatus clean.

It was not by a mere chance, however, that Faraday thus commenced his great career in the Royal Institution. While an apprentice he was an omnivorous reader, and early took delight in making experimental apparatus. In his nineteenth year he happened to attend a lecture on natural philosophy, and a little later heard several lectures delivered by Davy. This resulted in a great desire to engage in scientific work, and shortly afterward Faraday forwarded an application to the president of the Royal Society, for employment in any capacity, even the most menial. Receiving no reply, he addressed himself to Davy, who at first advised the youth to stick to book-binding, but several months later upon a vacancy occurring in the position of laboratory assistant, it was offered to Faraday and by him eagerly accepted, the engagement beginning Mar. 1, 1813.

The first years at the Royal Institution were years of preparation, and it was not until 1820 that he announced his first discovery, which was in chemistry.

In 1821, Wollaston conducted some experiments in the laboratory of the Royal Institute to realize an idea he had formed from Ampère's discoveries, that a conductor carrying a current could be made to rotate about the pole of a magnet and *vice versa*. In this he was unsuccessful, but Faraday, taking up the subject, finally succeeded in obtaining such rotation. This gave rise to an unpleasant feeling toward Faraday on the part of Wollaston and some of his friends, but the episode involved nothing discreditable to the character of Faraday.

The apparatus thus constructed by Faraday was the first electric motor; ten years later he constructed the first transformer and also the first dynamo—the Faraday disk.

In the period between 1821 and 1831, among other discoveries made in chemistry by Faraday was that of the element chlorine, in this case again acting upon the suggestion of another—Davy. During this period he became director of the Royal Institution laboratory and was much in demand for lectures and expert work, which gave him quite a large income for the times. In the latter year his great discovery of electromagnetic induction turned his mind definitely toward pure science as the sole object of his life, and thenceforth he permitted nothing to distract his attention from it.

In 1825 and 1828 he experimented to realize an idea he had conceived that since magnetism can be produced by electricity, as in the case of the solenoid, electricity in its turn ought to be capable of being produced by magnetism. Unsuccessful then, he again took up the subject in 1831, and on Aug. 29. of that year, he finally succeeded, making perhaps the greatest descovery of all time and laying the foundation upon which rests the great electrical development of the past 25 years.

MICHAEL FARADAY.

The apparatus used by Faraday in his memorable experiment consisted of an iron ring wound with two coils of bare wire, one about 72 ft. and the other 60 ft. long, the turns being separated by twine and the layers by calico. The longer coil was connected to a primary battery, and a loop of the other passed over a magnetic needle. When the battery circuit was made or broken, the needle was deflected one way or the other, by the induced current set up. This apparatus was the first transformer, combining every principle of the modern apparatus known by that name.

On Sept. 24 of the same year he discovered that a current was induced in wire coiled on an iron cylinder when a magnet was approached to the latter. On Oct. 1, he discovered that if a current passed through one of two adjacent coils on a block of wood was made or broken, a momentary current flowed in the closed circuit of the other coil.

This last-mentioned experiment led him to the generalization that "Electricity in currents, therefore, exerts an inductive influence like ordinary [static] electricity." Continuing his experiments, on Oct. 17, he generated current in a coil by merely inserting and removing a magnet. On Oct. 28, he made the first dynamo by revolving a disk between the poles of a magnet; when one end of the wire of a closed circuit was pressed against the circumference of the disk and the other against its axis, a continuous current was produced. It may be added that Prof. Forbes constructed a dynamo on the principle of Faraday's disk above-mentioned, which gave a current of 10,000 amperes at 1 volt, at 1000 r. p. m.

On the final day of his great experiments, Faraday found that by merely passing one side of a closed circuit between the poles of a magnet, a momentary current was induced in it. To explain all of the various phenomena observed, he conceived the idea of lines of magnetic force proceeding from a magnet, or surrounding a conductor carrying current; that when a conductor cuts such lines an E. M. F. is generated in it; and that the amount of this E. M. F. is proportional to the number of lines cut in a given time.

Of this hypothesis Faraday said that it "never failed to enable him to render a satisfactory and logical explanation of his results, and with this clue in hand he could find his way about the entanglements of experimental enquiry." To-day it remains the most satisfactory means of understanding all the phenomena of electromagnetic induction, both in connection with continuous and alternating currents.

It should here be remarked that Henry in August of 1831, independently discovered electromagnetic induction, his experiment being very similar to the first successful experiment of Faraday. He did not, however, follow it up, and knowledge of his work became lost until the republication of his papers more than a half century later.

Two other epoch-making discoveries are associated with Faraday's name—the laws of chemical decomposition and the magnetic rotation of the plane of polarization of light.

After a magnificent series of experiments he laid down the law known as Faraday's law, which formulates the relation between the strength of current and amount of any substance deposited by it. He showed that the current passing can be measured by the amount of electrolytic decomposition or deposition produced by it, or *vice versa*; and that, knowing the weight of one element deposited by a given current in a given time, the weight of any other element deposited by the same current in the same time is found by multiplying the known weight by the ratio of the chemical equivalents of the two elements.

The other discovery mentioned is most notable from having led to the electromagnetic theory of light, developed by Maxwell and experimentally proved by Hertz. Faraday found that if a ray of light was passed through certain media, and if these media were placed in a field of force, the plane of polarization was changed, being rotated through a definite angle for each substance and each strength of field. This principle has recently been used by Crehore and Squier in the construction of a chronoscope and in a system of rapid telegraphy.

Among other discoveries of Faraday was

that of diagmagnetism, or the property possessed by some materials whereby they place their polar axes at right angles to lines of force, paramagnetic bodies like iron placing their axes along such lines. He also conducted magnificent investigations into static electricity, among other work in this line, establishing the principles of the condenser.

Faraday united in a supreme degree the gifts of an experimenter and of a philosopher. He knew, not only how to question nature, but also how to interpret her answers. His insight of physical phenomena and their relations has never been equaled, and as a natural philosopher (which designation he preferred) he stands supreme in the history of science.

LESSONS IN PRACTICAL ELECTRICITY

FREQUENCY. MEAN AND EFFECTIVE E. M. F. AND CURRENT.

In the preceding article of this series it was pointed out that in the generation of alternating current, a sine-wave variation of E. M. F. and current is only obtained by a careful design of the apparatus. It was also pointed out that it is desirable for the sine wave to be approached as nearly as possible, since that form involves least inductive drop and furnishes a standard, without which motors would only run with entire success on lines fed by generators having the particular wave form for which the motor was designed. These reasons are weighty from the physical or practical standpoint and from the mathematical point of view, without the sine-wave assumption calculations would be so involved and difficult as to be impracticable. The simplicity which this assumption introduces will be seen in what follows.

In Fig. 1 *M D E* is a curve of alternating current or E. M. F. variation for one cycle. That is, it corresponds to the passage of a wire from midway between a south and north pole of a multipolar alternator, across a north pole and the adjacent south pole, to midway, again, between a south and north pole; or, it we call *A*, *B* and *C* three adjacent poles, the distance traveled is equivalent to the distance between the centers of *A* and *C*. It will be seen that this is a complete cyle, as at *E* (Fin. 1) another similar operation to that at *M* would be commenced. An alternation corresponds to half of a cycle, or to *M D* or *D E*; the distance traveled by a wire in the case of an alternation corresponds to the distance between the centers of two adjacent poles.

In all alternating-current calculations the frequency or number of complete cycles per second, enters, and not the alternations, or number of half cycles. It would be desirable if the idea of alternations were dropped entirely, as it conduces to confusion and does not appear to be of any use whatever. It would also be well if frequencies were always expressed in the number of complete cycles per second, as it is in this form that they are used in calculation. As an example, 7200 alternations per minute correspond to 60 cycles per second, or to a frequency of 60, it not being necessary to mention the time when the word frequency is used, as it is understood to refer to seconds. As another example, suppose we have a twelve-pole alternator making 600 revolutions per minute. The alternations, as usually expressed commercially, are the product of the *total* number of poles and revolutions per *minute*, or 7200 in this case; the frequency is the product of *half* the number of poles and the revolutions per *second*, or 60 in this case.

The maximum E. M. F. in an alternating current circuit is represented on an E. M. F. curve, by the distance from the upper to the lower crest of a cycle, or twice *A O* (Fig. 2), and not, as is often thought, by the ordinate, *A O*. In fact, from the physical standpoint, the datum line, *M D E*, should not cut through the middle of the curve as shown, but be tangent to the bottom crest; as this, however, would greatly complicate the mathematical treatment, the middle axis is always used. Since the curve of the cycle below the line is a duplicate to that above, any conclusions that apply to one apply to the other, and therefore in what follows only half of a cycle will be considered.

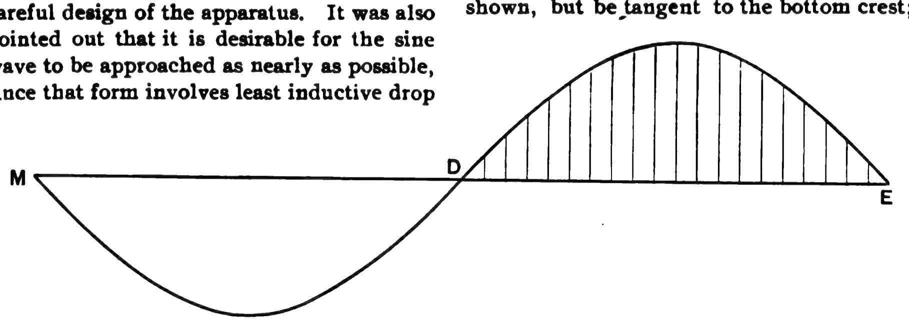


FIG. 1.—CURVE OF ALTERNATING CURRENT OR E. M. F.

If Fig. 1 represents current or E. M. F. the mean value could be found like that of an indicator card, by using a planimeter or by ordinates. If ordinates are used and the measurements very carefully made, it would be found that the length (Fig. 2) of the mean ordinate, *C O*, is equal to the length of *A O*, multiplied by .639. In other words, the mean ordinate of a sine curve is .639 times the maximum ordinate.

It happens, however, that in alternating-current calculations the mean value of the current or E. M. F. is not used, for reasons which will now be explained.

Ohm's law, $C = \frac{E}{R}$ may also be written, $CR = E$. Joule found that the amount of energy in the form of heat given up by an electric current having a value, *C*, in passing through a resistance having a value, *R*, is expressed by the product, $C^2 R$. This experimental demonstration of the relation between the value of a current and the energy which it carries, was afterwards shown to rest upon correct theoretical grounds. Returning now to our first equation, $CR = E$, and multiplying each side by *C*, we find that, $C^2 R = CE$, so that the latter is another expression for the amount of energy in an electric current; also, taking the ordinary form of Ohm's law, $C = \frac{E}{R}$ and multiplying by *E*, we have, $CE = \frac{E^2}{R}$, which is a third form of expression for the amount of energy in the current.

Now, since *R* is a constant in a given circuit, we see from the expressions, $C^2 R$, and $\frac{E^2}{R}$, that the energy varies as the square of the E. M. F. or the square of the current.

In all practical calculations we wish to know the values of the current and of the E. M. F. which correspond to their capacity for doing work—that is, for producing light, heat or mechanical power. This value of the current or E. M. F., generally called the *effective* value, differs from the mean value, and is obtained as follows:

Suppose in Fig. 1 the current represented by the curve is passing through a resistance of 1 ohm; then the rate of work corresponding to any ordinate would be the square of that ordinate into the resistance; and the total energy of the alternation would be the sum of all these products. If, now, we divide this by the resistance assumed, we will have the sum of the squares of all the different values of the current represented by the ordinates, and dividing this by the number of ordinates, the result will be their mean square. If, now, we take the square root of this latter quantity, we will have what is called the effective current.* Similar reasoning applies to effective E. M. F.

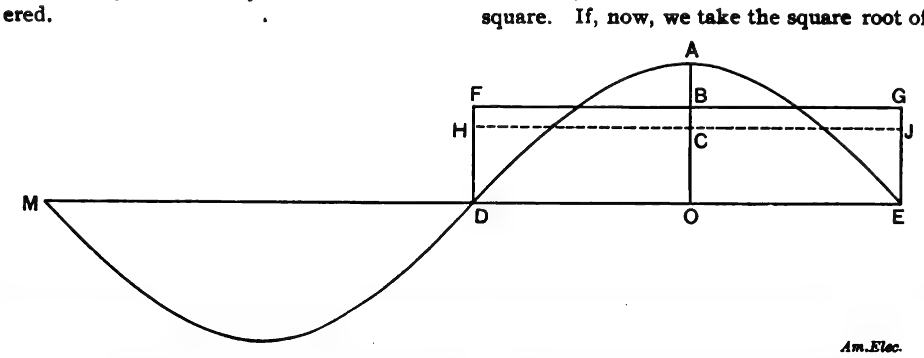


FIG. 2.—SHOWING MAXIMUM, MEAN, AND MEAN SQUARE ORDINATES.

*Mathematically expressed, $C_{eff.} = \sqrt{\frac{C_1^2 + C_2^2 + C_3^2 + \ldots}{n}}$, where C_1, C_2, etc., are the above ordinate values of Fig. 1, and *n* the number of ordinates.

To illustrate the difference between a mean ordinate and what is called a mean square ordinate, suppose we have two ordinates, the value of one being 3 and of the other 4. The mean of these two ordinates would, of course, be one-half their sum or 3½. To find their mean square value we square each and add, which gives us 25; extracting the square root, we have 5, or the mean square value is considerably larger than the mean value.

Referring to Fig. 2, *A O* is the maximum ordinate, *C O* is the mean ordinate, and *B O* is the mean square ordinate, being, it will be seen, larger than the mean ordinate. If the value of *A O* is 1, then the value of *B O* is .707, and the value of *C O*, .639; or, to put it another way, if the value of *B O* or the mean square ordinate, is 1, the value of *A O* is 1.41. As the mean ordinate does not enter into ordinary calculations, it will not be referred to again.

B O is half the value of the current or E. M. F. as read by an alternating-current ammeter or voltmeter. Suppose the E. M. F. reading were 1000, then *B O* would be 500 and *A O* would be 1.41 times this or 707 and the total maximum E. M. F. would be twice this or 1414. It is unnecessary, of course, to include in calculations the half values, and we can say generally that the maximum E. M. F. in an alternating current is 1.41 times the effective value, which is the value that is indicated by an alternating-current ammeter or voltmeter, and also the value which corresponds to the capacity of the E. M. F. or current for doing work.

While the maximum value of an alternating-current or E. M. F. does not usually require to be considered, yet there are occasional effects which are functions, not of the effective, but of the maximum E. M. F.

For example, the strain on the insulation of a conductor is proportional to the maximum E. M. F. and not to the effective E. M. F. That is, while a continuous current of 1000 volts, or an alternating current of 1000 volts effective, may in a circuit be doing exactly the same work, yet the strain on the insulation in the case of the alternating current will be 1.41 times greater than in the case of the continuous current, or will correspond to a continuous-current voltage of 1410 volts. It should be remarked, however, that the continuous current introduces a constant electrolytic strain which may more than overbalance the greater electrostatic strain due to the higher maximum alternating voltage.

In the case of an electric shock also, the maximum E. M. F. enters, so far, at least, as the initial shock received by the body is concerned, and frequently it is the initial shock which kills. Thus a shock from an alternating current of 1000 volts effective has the same initial effect as a shock from a continuous current of 1410 volts. With alternating currents the shock is repeated with every cycle, but with little or no electrolysis; on the other hand, there is no repetition of the shock with a continuous current, but there is electrolysis, which may be quite as deadly in its effect. Consequently no general conclusions seem possible from the premises here considered in regard to the relative danger of continuous and alternating currents.

Letters on Practical Subjects

Dynamo Bell Ringing.

To the Editor of American Electrician:

The illustration herewith presented, shows a plan for ringing bells, operating fire-alarm signals, watchmen's clocks, etc., in a mill by dynamo current while that machine is running. The device also automatically switches out the dynamo and cuts in a battery when the electric generator stops running, thus effecting quite a saving of battery material, which, being operated only a short time each week, will last a long time, as a good open-circuit battery loses nothing when not at work.

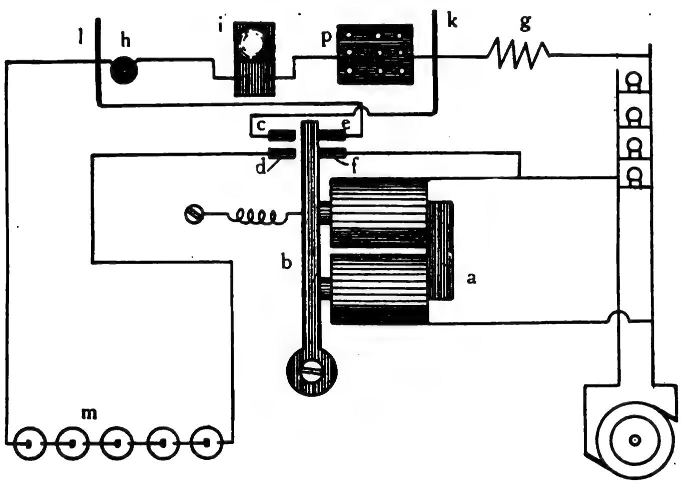


DIAGRAM OF DYNAMO-BELL CIRCUIT.

The double-pole relay (double-contact), *d*, is connected direct to the dynamo leads as shown, so that the electromagnet is always charged while the dynamo is running—and at no other time. Consequently the armature, *b*, is in the position represented and a circuit is closed through the spring contacts, *e* and *f*, to the main signal wires, *l* and *k*. Between these leads any bell system, fire-alarm or time-detecting apparatus may be connected, as shown by the simple system, *h*, *i*, *j*, consisting of push-button, bell and annunciator.

When the dynamo stops running, the armature, *b*, is pulled back by the spring, making contact between *c* and *d*, and allowing the various systems to be operated from the battery shown at *m*.

Pittsburg, Pa. S. L. CORSON.

"Double-end" Switch Arrangement.

To the Editor of American Electrician:

The accompanying sketch illustrates a handy electric-lighting "kink" where long rooms or passages have to be lighted, especially when it is desired to turn on the lights upon entering at one end of the room, and to turn them out upon reaching the other end of the room or passage. The illustration shows an ordinary pair of dynamo leads, *f* and *g*, from which branches are taken at any convenient places, say, at *h* and *i*, and carried to the switches, *j* and *k*.

Two contact points are arranged for each switch, say, *b* and *c* at *k*, and *d* and *e* at *j*. Wires are run from *b* to *d* and from *c* to *e*, and lamps *a*, *a*, *a*, put in parallel between them in the usual manner. When the switches are in the position shown in the engraving, the lamps will be all connected between *i* and *h*, but if either switch be moved, the lamps will go out. If switch *j* be moved to *d*, the lamps will all be out of circuit, but may be cut in again from either switch.

Brooklyn, N. Y. JAMES F. HOBART.

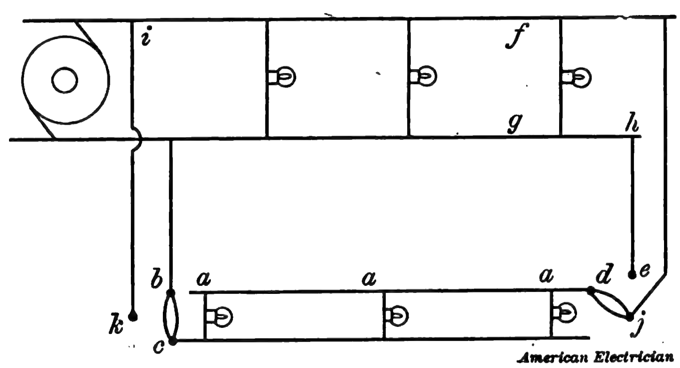


DIAGRAM OF SWITCH ARRANGEMENT.

A New Type of Fuse Cut-Out.

To the Editor of American Electrician:

Scarcely a week passes without the introduction of a new form of cut-out on the market, but few of them embody any really new idea or any radical improvement in the action of the fuse itself. While we do not claim that the idea to be described is an entirely new one, yet in the form and way in which it is applied, it differs from any fuse block of which we have a knowledge. There is an English fuse which has a small weight attached to its center, for much the same purpose as the tension member shown in the cut; and we have lately heard of some experiments in which springs were used merely to separate the terminals, so as to increase the space across which an arc would have a tendency to form when the fuse was ruptured.

The point of difference between the fuse block which we used in our tests, and that of ordinary practice, lies in the addition of a

means of producing tension on the fuse wire while in circuit. For convenience in the trials, a rubber band was the tension member, and as applied as shown in Fig. 1, answered the purpose very nicely, holding out during the entire series of tests. In the cut F is the fuse, T-T' are terminals, P-P', pivotal points, c-c', copper strips, s-s', screws and R a rubber band.

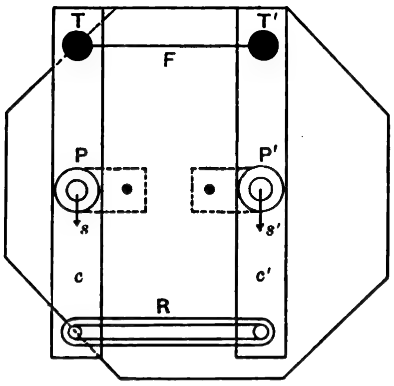


FIG. 1.—FUSE CUT-OUT.

To any one who has closely examined the action of a fuse when subjected to several times the current for which it is rated, it is apparent that such an arrangement as the above would tend to make such action more uniform, and this our tests show to be the case.

To see just why this is so, we will refer to one instance in which a 1-ampere fuse wire was placed in a block exposed to the air in a warm room, with the terminals 2¼ ins.

FIG. 2.—FUSE WIRE.

apart. When 3.2 amperes were sent through the fuse, it melted in a few seconds, but remained intact in somewhat this shape for 3½ minutes, although free from contact with the porcelain, and would probably have remained as much longer had not the block been vibrated slightly to expedite the experiments.

It is unnecessary at this time to enter into any detailed discussion of the causes of the unreliability of fuses, as this subject has been thoroughly treated by Prof. Wilbur M. Stine* and others who have made a study of it.

The tests were all made with fuse wire marked 1 ampere. The reason for using this size was, that it had been suggested that our form of fuse block would introduce another uncertain feature in the action of the fuse, namely, the tensile strength. But in all the tests the wire did not break once while cool, yet the tension was strong enough to decidedly open the contacts.

In comparing the two sets of tests—that is, with and without tension—the same fuse block was used; the copper strips cc' being fastened down by means of the screws, s, s', so that the length of fuse and radiating surface remained practically constant. The length of fuse tested was 2 ins.

With tension on the fuse, and the current maintained constant at 2.5 amperes, it blew in an average of twenty-four seconds, with a variation of eight seconds in the readings.

Without tension and a constant current of 3.2 amperes, the fuse blew in an average of sixty-nine seconds, with a variation of 187 seconds in the readings.

With tension and current slowly increased, the fuse ruptured at an average of 6.6 amperes, with a variation of .7 ampere in the readings. When current was quickly increased, the average was 9.4 amperes, and the variation .4 ampere.

Without tension and current slowly increased, the fuse ruptured at an average of 6.2 amperes, with a variation of 1 ampere. With current quickly increased the average was 9.3 amperes, with a variation of 7.5 amperes.

For commercial purposes the fuse block could be made similar to almost any of the present forms, with slight modifications.

The reader is left to form his own conclusions from these tests as to the merits of such a cut-out.

Philadelphia, Pa. W. SONNEBERG.

*AMERICAN ELECTRICIAN, May, 1896.

ELECTRICAL CATECHISM

148. Can several circuits be supplied at different voltages by the same alternator?

This may be done by the use of "boosters" or adjustable transformers connected in the vari us lines. Alternators having stationary armature coils may be provided with a number of terminals so that any circuit may be connected around any desired number of armature coils.

149. What is a booster?

When speaking of continuous currents, a booster is a small dynamo connected in series

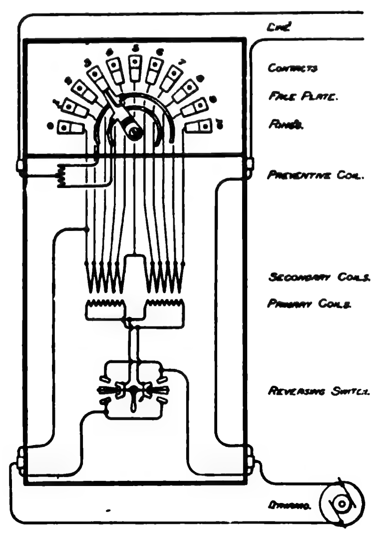


FIG. 1.—DIAGRAM OF BOOSTER.

with a line so that its electromotive force is added to the voltage across the terminals. When speaking of alternating currents, the booster is a special transformer whose secondary is connected in the line to raise or lower the voltage. The secondary coil has several terminals for adjustment and the primary coil is connected through a reversing switch so that the secondary will either raise or lower the voltage on the line. A diagram of the Westinghouse booster is given in Fig. 1. A simpler diagram omitting the switches is shown in Fig. 1.

150. What is a choke coil?

A choke coil is a sort of transformer having a single coil surrounding a laminated iron core. Usually the coil has a number of

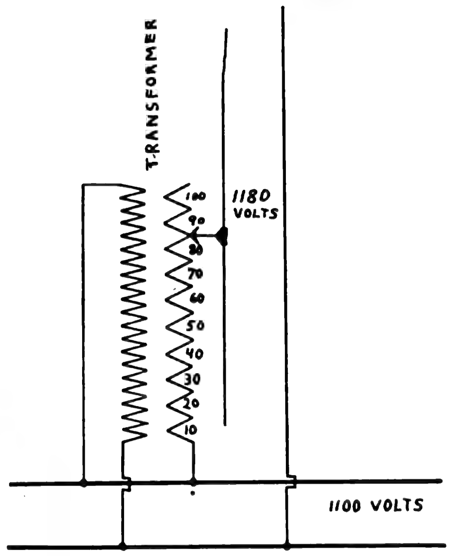


FIG. 2.—DIAGRAM OF CHOKE COIL.

terminals so that the number of active turns of the coil may be varied, as shown in Fig. 2.

151. For what purposes is a choke coil used?

For reducing the voltage and current in a circuit. The self-induction of the choke coil acts as a counter E. M. F. or "back voltage" opposing the impressed or line voltage and thus reducing the current. For example, a choke coil may be connected in series with a group of incandescent lamps in order to dim them.

152. What advantage has a choke coil over a resistance coil?

The resistance coil reduces the current on a line by increasing the resistance, but at the same time absorbing a considerable part of the energy. For example, suppose a group of lamps on a 110-volt circuit takes 10 amperes; or 1100 watts. The resistance of the lamps is $R = \frac{E}{C} = \frac{110}{10} = 11$ ohms. Now suppose a resistance of 11 ohms is in-

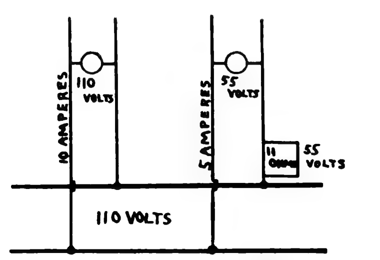


FIG. 3.—CIRCUIT WITH RESISTANCE IN SERIES.

serted in series with the lamps as indicated in Fig. 3. The total resistance is $11 + 11 = 22$ ohms, the current is $C = \frac{E}{R} = \frac{110}{22} = 5$ amperes, and the total energy is $W = C^2R$

$= 5 \times 5 \times 22 = 550$ watts. The energy used in the lamps is $W = C^2 R = 5 \times 5 \times 11 =$ 275 watts or only half the total energy, while the balance of 275 watts is absorbed by the resistance. By inserting an equal resistance, the energy used in the lamps is reduced to one-fourth while the total energy taken by the circuit is reduced to one-half. In other words, while the added resistance reduces the total energy taken by the circuit, it also wastes a large part of what is taken. On the other hand, the choke coil also reduces the total energy taken by the circuit, but does not waste much of it.

153. Is a choke coil suitable for direct currents?

No. It is used only with alternating currents. With direct current it would act only at a very low resistance and would not materially reduce the voltage or the current.

154. How can a choke coil reduce the current without wasting energy?

The choke coil sets up a counter E. M. F. which not only reduces the current, but also causes the current waves to lag behind the E. M. F. waves. The energy actually used is the product of the current by the component

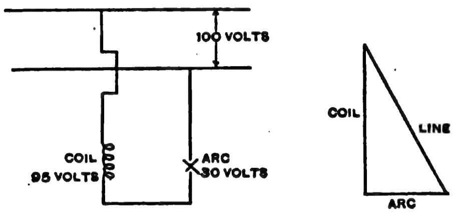


FIG. 4.—CIRCUIT WITH INDUCTANCE IN SERIES.

of the E. M. F., which is in the same phase. This may be illustrated by Fig. 4, which shows a method of operating an alternating arc lamp at 30 volts on a 100-volt circuit. If the lamp circuit takes 10 amperes, the energy in the arc is very nearly $W = E\,C =$ $30 \times 10 = 300$ watts, while the apparent energy taken by the coil is $W = E'\,C =$ $95 \times 10 = 950$ watts, and the apparent energy taken by the circuit is $100 \times 10 = 1000$ watts. The real energy in the circuit is practically 300 watts.

QUERIES AND ANSWERS

How may ampere-hours be read on a wattmeter? W. T. M.

The wattmeter reading divided by the average voltage of the circuit will give the ampere-hours.

What is the cause of a perfectly clean carbon rod of an arc lamp hanging up A. G. W.

The shunt coil is most probably out of order and the series coil has everything its own way. Such a lamp will sometimes feed correctly, but will flicker and chatter.

How is tungstate of calcium made? J. G.

Mix tungstate of soda with common salt and melt the mixture; then wash out the remaining salt. If a chemist, you will probably be able to get a good result, but otherwise it is doubtful. Enough tungstate of calcium to make a 6 in. $\times$ 6 in. Röntgen screen can be bought for twenty-five cents.

1°. What is the resistance of a 10,000-ohm magneto armature coil? 2°. How can I change a 10,000-ohm into a 15,000-ohm magneto? G. H. E.

1°. About 1000 ohms. A quarter pound of No. 36 wire is sufficient. 2°. You can increase the voltage of a 10,000-ohm magneto by rewinding its armature with more turns of wire, about in proportion to the increase desired, and using a bell sensitive to smaller currents.

How can a storage cell be charged on a 500-volt railway circuit? W. W. S.

Put several series of five 100-volt, 32-CP lamps in parallel, the group being between the line and the ground. It is doubtful, however, if any railway manager will allow this to be done. The simplest way would be to put the cell in a dynamo shunt circuit, the few volts of the cell having little effect on such a circuit.

Why have large transformers a less number of primary turns than small ones? W. H. W.

For the same reason that as the field of a dynamo becomes stronger, the number of armature wires becomes less. In a large transformer there are more lines of force than in a small one; during an alternation all of the lines are cut in or cut out of the coil, and there must be fewer turns in the case of large transformers in order that the total number of cuttings, and consequently the E. M. F., may remain the same in each case.

1°. I have a small 8-pole induction fan motor wound for 110 volts, 125 cycles. What change must be made to run the motor on a 50-volt circuit? 2°. Can it run on a three-phase circuit? E. S.

1°. Divide the eight field coils into two sets of four and connect them in multiple. Care should be taken not to neglect the little close-circuited copper rectangles that fit over one-half of the pole-pieces. 2°. The motor is not made for three-phased circuits because the number of pole-pieces is not a multiple of three. It can, of course, be run on one leg of a three-phased circuit.

How can a 10-light Wood automatic arc dynamo be changed to a series motor for a 212-volt circuit? J. K. W.

It is rather impracticable to do so, as the magnetic circuit is not designed for such service. The armature would have to be rewound with wire about twice its present size and half the number of turns. The field winding can be divided into two equal parts and joined in parallel. You might make a trial with the present armature winding, short-circuiting the commutator bars by pairs and shifting the positive wire of the dead bar to, say, the left, and the negative wire to the right, adjacent bar.

What is the E. M. F. at the negative binding post of a 2500-volt arc dynamo? F. B.

A point cannot have an E. M. F. since E. M. F. is the difference between the potentials that exist at two points. The potential of the point is 2500 volts with reference to the positive binding post, 50 volts with reference to the far terminal of the nearest lamp, 500 volts with reference to the tenth lamp, and so on, it being necessary to have a point of reference in order to express the potential. If we consider the potential of the earth zero, then if the tenth lamp from the negative post is grounded, the potential of that post will be — 500 volts, and of the positive post + 2000 volts.

Is it practicable to electro-plate with a 110-volt current? W. H. W.

An ampere is an ampere whether there is one volt or 100,000 volts behind it. The voltage is the force which causes the current to flow, and is high or low according to the resistance or counter E. M. F. to be overcome. The resistance of a plating bath is very low and therefore the voltage is low. By putting in auxiliary resistance, such as incandescent lamps, all but a fraction of the voltage will be used up in sending the current through the lamps. One 110-volt, 16-CP lamp is sufgcient for from 15 to 30 sq. ins. of surface to be plated with silver, or 8 sq. ins, for copper plating in acid bath.

How may a cheap battery be made? J. H.

Suspend a flat zinc plate (which has been amalgamated by dipping in dilute sulphuric acid until it begins to sizzle and then rubbing the wet surface with mercury) between two rows of electric-light carbons fitted into augur holes in a board; or bend the plate in circular form and suspend within a cylinder formed of carbon rods. Care should be taken that the zinc does not touch the carbons. The board carrying the carbons should be put in a glass or earthen jar containing a saturated solution of bichromate of potash, to which one-tenth part of sulphuric acid has been added. The zinc should only be in the solution when the battery is being used.

Why are the brushes of an Edison incandescent, right-hand dynamo moved in a direction opposite to those of a Wood right hand arc dynamo? W. D. W.

The only reason for moving the brushes of an incandescent machine is to adjust them to a non-sparking position, which position continues to advance in the direction of rotation as the load comes on, and thus sometimes necessitating a corresponding movement of the brushes. The brushes of an arc machine are moved only for the purpose of voltage regulation, and if they are forward of the point of highest voltage they will have to be moved back if the voltage is to be increased; if they are back of this point of high voltage, the reverse will be the case. The operating zone of the Wood machine is confined to one side of the point of maximum potential on the commutator.

1°. I have removed the plugs from some $5\frac{1}{2} \times 7\frac{1}{2}$ negative storage battery plates, and wish to refill them for positives; will it be necessary to first peroxidize the empty grids by charging them as positives in an electrolyte? 2°. What is the probable capacity of a cell of 3 positives and 4 negatives of the above plates?

1°. You can repaste the grids without peroxidizing. If the negative plugs were in good condition, it would have been better to leave the plates intact, as negatives are very easily converted into positives by the action of the charging current, and make better positives than freshly pasted grids unless the pasting and forming are done exactly right. 2°. If the cells be discharged at the rate of $2\frac{1}{2}$ amperes per positive plate, or $7\frac{1}{2}$ amperes per cell of 7 plates such as you describe, they ought to last for 8 hours. At 5 amperes per plate or 15 amperes per cell, 3 hours would probably be the limit.

In the answer to G. J. in July issue, the reluctance of an air gap per square inch area and 1 in. length, should be .4 oersted instead of, as printed, 1 oersted.

New Apparatus and Appliances.

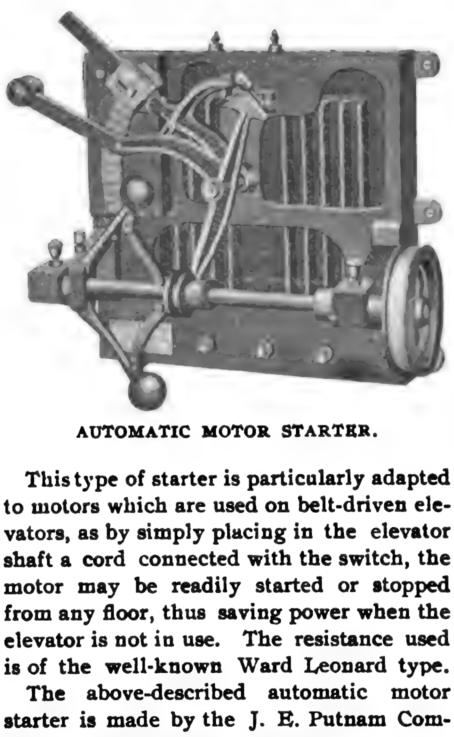
AUTOMATIC MOTOR STARTER.

The automatic motor starter illustrated herewith is so simple as to need very little description to enable its action to be understood.

It is driven by a belt running from any shaft driven by the motor and its operation is entirely mechanical and positive. The balls seen in the illustration move a lever with two arms, one of which catches a projecting lug on the contact arm and carries it with it until the resistance is all cut out, in which position the contact arm is latched by the curved projection.

Changes in speed caused by variations of load within the rated power of the motor, simply cause the operating arm to play slightly.

When the reduction in speed is great, as from an overload, the beveled projection on the operating lever releases the latch and allows the contact arm to cut the resistance into the armature circuit, thus protecting it. To start the motor with or without load, it is only necessary to close an ordinary switch, which may be situated at any point.



AUTOMATIC MOTOR STARTER.

This type of starter is particularly adapted to motors which are used on belt-driven elevators, as by simply placing in the elevator shaft a cord connected with the switch, the motor may be readily started or stopped from any floor, thus saving power when the elevator is not in use. The resistance used is of the well-known Ward Leonard type.

The above-described automatic motor starter is made by the J. E. Putnam Company, 123 State Street, Rochester, N. Y.

GAS ENGINE FOR ELECTRIC LIGHTING.

The gas engine of which two views are given in the accompanying cuts, has been especially designed for operating dynamos, the necessary uniformity of speed for this purpose being secured by a new and highly efficient design of governor and valve motion.

Referring to Fig. 2, the charge of air and gas is drawn on a forward stroke through the poppet valve shown in plan, passing into the cylinder through the end port. On the return stroke of the piston, the valve shown on the end of the valve rod closes the passage from this port, and the firing mixture is compressed; just as the piston starts on another forward stroke, the charge is ignited, driving the piston to the end of its stroke, at the extreme end of which the portor supplemental exhaust, *H*, is uncovered, and at the same time the valve at the other end of the cylinder opens, thus giving two exits for the exhaust. As the piston makes its return stroke, the port, *H*, is covered, the remaining burnt gases are forced out of the end port or main exhaust, and another four-stroke cycle begins.

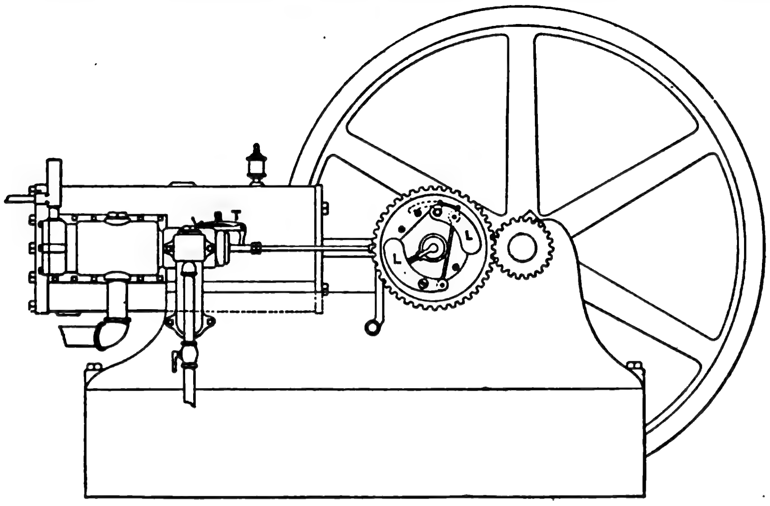


FIG. 1.—OLIN GAS ENGINE.

The governor, as will be seen from Fig. 1, is of the wheel type used on automatic steam engines. When the speed exceeds a predetermined amount, the weights, *L*, fly out, and by means of a very simple mechanism, act on the valve motion in such a manner that the exhaust is held open and the valve admitting the charge is kept on its seat; as a consequence, the engine does no appreciable work, no part of a charge is wasted, and the speed drops to normal, when a charge is again admitted. The engine has two heavy fly-wheels, which assist the governor in preventing any perceptible variations in speed. The charge is fired by electricity or, preferably, by an incandescent igniter, shown in Fig. 1.

The high efficiency of this engine enables the makers to guarantee, for machines of 10 HP and above, a consumption of 15 cu. ft. of good gas or one pint of gasoline per indicated HP-hour. Referred to equivalent gas and electric illumination, this figure brings out very strongly the economy of the engine described for electric lighting. Fifteen cubic feet of illuminating gas burned in jets will supply three 16-CP jets for one hour; on the other hand, the lowest figure given for incandescent lighting is ten 16-CP lamps per HP. That is, from a given quantity of gas more than three times as much light may be obtained if, instead of being burned from jets, it is used to drive a gas engine of the efficiency of the one described, the engine in turn driving a dynamo feeding incandescent lamps. For arc lighting the ratio is more than 12 to 1.

The Olin gas and gasoline engine is made by the Olin Gas Engine Company, Buffalo, N. Y.

MULTI-CIRCUIT ARC DYNAMO.

The accompanying cuts illustrate a new type of arc dynamo invented by Mr. S. W. Rushmore, one of which has been in successful use for some time. As will be seen from the illustrations, each machine will supply a number of independent circuits, and each circuit is automatically regulated.

The field is somewhat different from the ordinary construction; the pole-pieces are secured to a common field ring, but arranged in pairs with each pair magnetically separated from the others. The armature and poles are so proportioned that the section embraced by a single pair of poles will have sufficient capacity to supply a circuit of arc lamps at the required voltage—the machine,

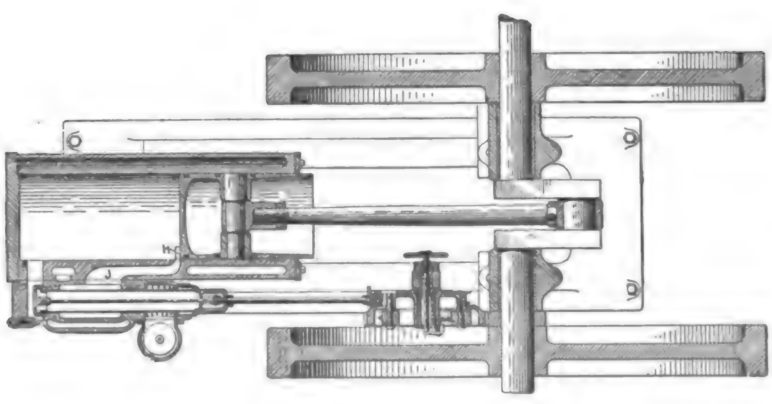


FIG. 2.—OLIN GAS ENGINE.

in short, being a number of arc machines incorporated in a single unit with an armature common to all.

The brushes of the machine are arranged

to collect the current from the armature under but a single pole of each pair of magnets, instead of under both poles. In this way as much current is collected from a section of the armature under a single pole as under both poles, while the "idle" pole serves to keep the flux from flowing to the other sections. No matter how much current is drawn from the armature under one section or separate magnet, there is no effect

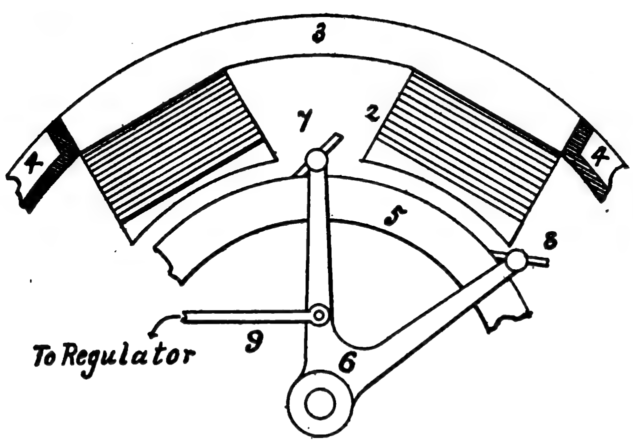


FIG. 1.—SECTION OF MULTIPLE-CIRCUIT DYNAMO.

upon the other sections, and each section and pair of brushes supplies an independent circuit with varying current or pressure entirely independent of all other sections.

In Fig. 1 is shown a section of the machine. The ring armature with poles 1 and 2 are connected by the yoke-piece 3; 4, 4 are non-magnetic sections joining a magnet with other similar magnets to form a complete field. 5 is a section of the armature and 6 a brush-rocker carrying brushes 7 and 8, which

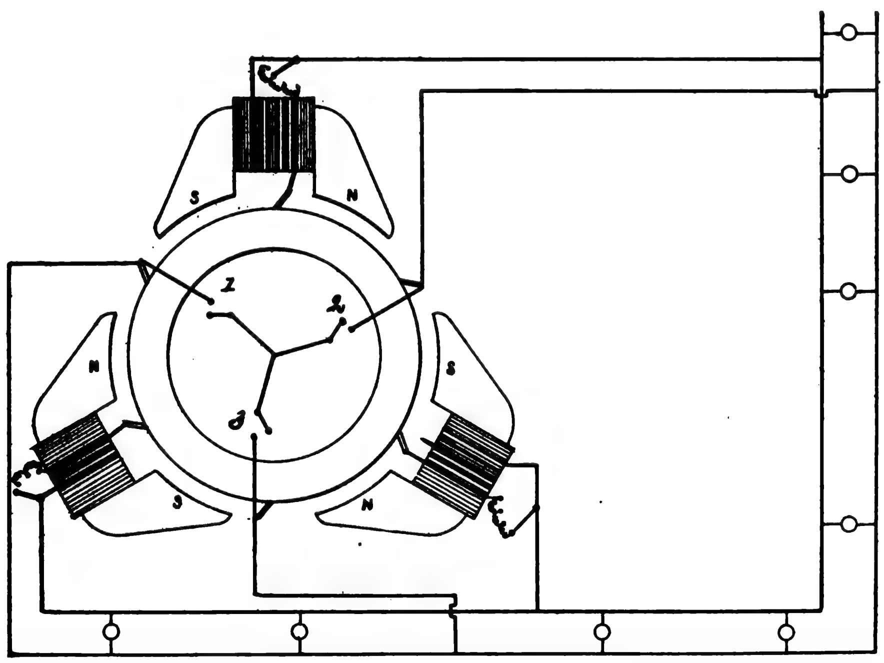


FIG. 2.—MULTIPLE-CIRCUIT DYNAMO.

are adapted to include between them the armature coils under pole 2; 9 is a bar or lever from a regulator adapted to shift the brushes in the usual manner. When the circuit supplied from the brushes is at its maximum voltage, the brushes will be shifted to a position with pole 2 nearly central between them, and as lamps are cut out and less voltage is required, the regulator will shift the brushes towards pole 1, thus distorting the field from pole 2, to keep down the voltage, as in bi-polar machines.

As the current in the armature under pole 1 is only the very small amount that will find its way around the armature under all the other poles from brush 7 to brush 8, there will be little or no distortion of the field of pole 1, and there will be no interference with the working of the adjacent section which may be supplying a different circuit.

It has been found that machines constructed on this new principle have very little tendency to flash and have such wide inherent regulation that very little work is required of the regulator. The machine may be built with a large number of poles to supply as many circuits as desired and be connected direct to an engine. In appearance it resembles common types of multipolar generators except that the brushes for each pair of poles are connected to a regulator.

The principle may also be applied to any service where it is desired to have a single machine supply current at two or more different pressures for lighting, railway work, etc. The machines may be built in large units to deliver their entire output at a single voltage, or at as many different voltages as there are pairs of magnet-poles surrounding the armature, and the voltage adjusted instantly to any amount required. Thus one or more sections of the machine may supply the main station bus, while other sections may be connected to feeders and be compounded for any loss desired,

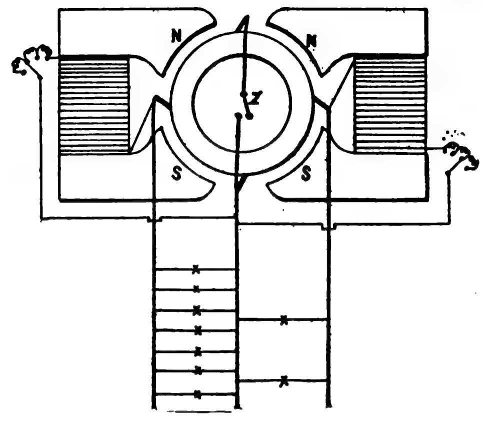


FIG. 3.—MULTIPLE-CIRCUIT DYNAMO APPLIED TO THREE-WIRE SYSTEM.

thus dispensing with boosters and special high-pressure machines for long feeders.

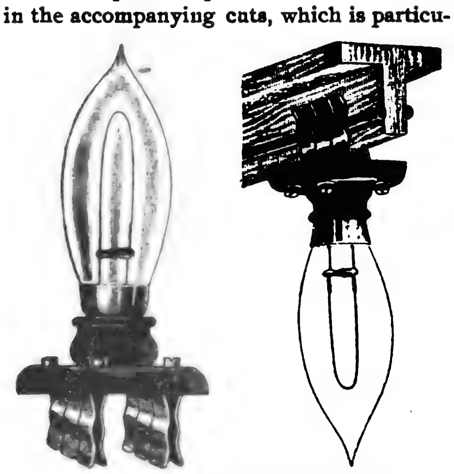
This is shown in Fig. 2, in which 1, 2 and 3 are switches adapted to cross connect the brushes, so that the current may be collected directly under a single pole of each pair or under as many poles as desired.

Fig. 3 shows the machine as applied to the three-wire system, in which case it is practically two machines in series, and the load may be entirely removed from one side of the system, without in the least affecting the voltage supplied by the machine to the other side, which may be fully loaded. In Fig. 3, 1 is a switch adapted to connect the brushes, so that the current may be collected under other than a single pole of each pair; this switch would be opened only when the system was so badly out of balance as to make it necessary to collect under one pole, as already described.

The new type of machine described is the invention of Mr. S. W. Rushmore, of the Rushmore Dynamo Works, Jersey City, N. J.

LAMP SOCKET FOR TEMPORARY INSTALLATIONS.

An European lamp base or socket is shown in the accompanying cuts, which is particularly intended for use in connection with temporary outdoor or indoor illumination.

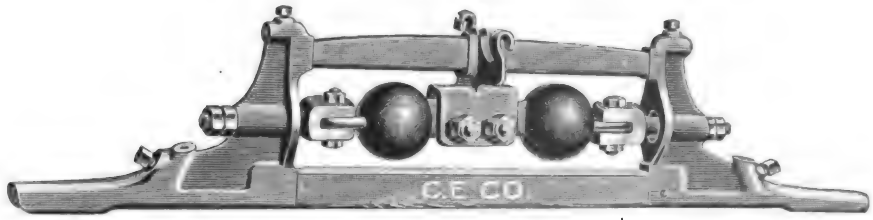


LAMP SOCKET FOR TEMPORARY WORK.

There are two clips fixed to a porcelain base, by means of which the lamp is held in place and contact made. The bare conducting wires may be run as shown for outdoor work, or secured to knobs, the distance apart in either case being about two inches. The manufacturer of the base and type of lamp shown—Berthold Groote, Nuremberg, Germany—claims that one man can put up or take down 300 lamps per hour.

CENTRAL-SECTION RAILWAY INSULATOR.

The new type of central-section insulator shown herewith, which can be applied to all the usual sizes of trolley wire, has a breaking strain of 5000 lbs., and is so constructed as to offer to the trolley a perfectly straight under-run. It has been designed to have the greatest strength with the least weight. The design, as will be seen, is mechanical in appearance, and has met the approval of leading electric railway engineers. This appliance is made by the Central Electric Company, Chicago.



OVERHEAD INSULATOR.

ATMOSPHERIC RANGE RECORDING THERMOMETER FOR CLOSED SPACES.

The instrument herein described has been developed to meet a demand for a recording thermometer for atmospheric ranges of temperature that can be applied to air, gases or liquids in a closed pipe or room. Fig. 1 shows the complete instrument, which consists of a Bristol recording pressure gauge in which the helical tube is completely filled with an expansible liquid. This tube, which is sensitive to, and is operated by, changes of temperature, is inclosed in the cylinder projecting from the back of the case of the recorder, as shown in Fig. 1. The cylinder containing the sensitive tube is furnished with a screw-thread so that it may be conveniently located within a gas main, through the side of a tank, or through partition of a room as may be required. Fig. 2 is an outline of one of the thermometers as applied to a large gas main; A represents the protected sensitive bulb; B is a cross section of the gas main, and C the recording portion of the instrument.

FIG. 1.—RECORDING THERMOMETER FOR CLOSED SPACES.

FIG. 3.—SPECIMEN OF RECORD.

It will be observed that the operative part of the instrument is entirely protected from any action of the gases or liquids of which the temperature is being recorded, and hence the operation of the instrument is independent of the pressure or vacuum within the closed space.

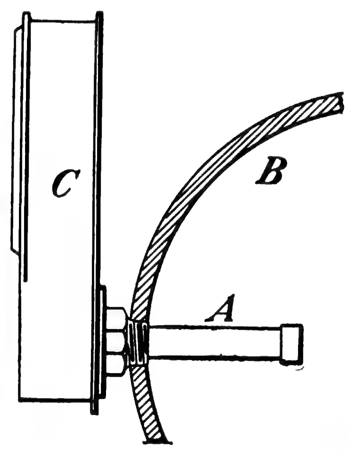


FIG. 2.—THERMOMETER AS APPLIED.

Fig. 3 shows a specimen section of the chart of these thermometers for a range from 0 to 130 degs. F. Other ranges may be made by using weaker or stronger pressure-gauge tubes. By varying the quantity of the expansible liquid inclosed in the pressure tube, the lower end of this scale may be limited and a very open scale provided at the normal degree of temperature.

These thermometers have been in successful operation for several months. They are being manufactured and placed on the market by the Bristol Company, of Waterbury, Conn.

FUSIBLE WALL SOCKET.

The device shown herewith consists of a standard Bryant socket mounted on a K. W. rosette, making a combination whose usefulness will be appreciated by the electrician. The shell of the socket is held in place on the base by three bayonet joints, which makes it thoroughly rigid and solid, capable of supporting any weight of shade or lamp without sagging. The socket, being fitted to the rosette cap, can be used with any of the regular rosette bases, all caps being interchangeable. The rosette, of course, is fusible. The fitting described is made by the Bryant Electric Company, Bridgeport, Conn.

FUSIBLE WALL SOCKET.

IMPROVED SAMSON CELLS.

The Samson battery, one of the oldest and most prominent open-circuit cells, has recently been changed, as shown by the accompanying illustrations. These changes, which have made a great improvement in the battery, have been mainly mechanical. The carbon connection, which, should occasion require, could not be renewed in the old style, is now made removable, and is larger and stronger and tinned to prevent corrosion. The carbon, of French production, is hollow and filled with a depolarizing compound, as shown in Fig. 1. It is made with a screw-top, which fastens securely into a threaded cover.

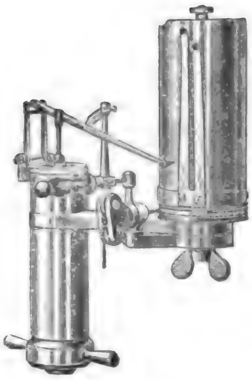
The zinc has also been changed, and now has three projections at the top, which fit into a groove in the cover, and is held firmly in place against it by a large knurled nut placed on the zinc stem. This arrangement admits of placing the elements in position before shipping, and the only necessary handling after taking the cell from the packing-case is to remove the excelsior from around the elements and replace them in the

IMPROVED SAMSON CELL.

jar, after having first added the sal-ammoniac solution. The rubber plugs and bands used in the old style, which collected the salts formed during action and were liable to allow a short circuit to be made between the elements if care were not used, are thus dispensed with. The battery is made by the Electric Gas Lighting Company, of Boston, Mass.

BUFFALO INDICATOR.

In the indicator illustrated herewith the working parts have been reduced to a mini mum and made of such light weight that a quick response to the steam pressure is always assured. A new style of double coil



BUFFALO INDICATOR.

spring of high tension is used, and all parts of the link motion are made of tool steel. The upper part of the piston rod, which is hollow, is threaded to receive a swivel head, which permits of the adjustment of the pencil to the spring. For use where exposed to ammonia, parts of the indicator are made of a special composition. This steam appliance is made by the Buffalo Indicator Company, 50 Lakeview Avenue, Buffalo, N. Y.

THE OGDEN (UTAH) POWER TRANSMISSION.

The power plant of the Pioneer Electric Company, of Ogden, Utah, one of the largest works of the kind yet undertaken, has in part been completed. The complete plan contemplates the utilization of the waters of the Ogden River water shed, the central features being a storage reservoir, of 2000 acres and a capacity of nearly 15,000,000 gals.; a pipe conduit, 6 ft. in diameter internally; a power house and water-wheels and electric generators, transmission lines and substations for distributing the power to different points; and an extended system of irrigation lines.

The main conduit, has, as stated above, an internal diameter of 6 ft., and a total length of 31,600 ft., of which 27,000 ft. are of wooden stave and 4600 ft. riveted steel pipe The line passes through eight tunnels, the longest being 667 ft., and over steel bridges of a total length of 560 ft., besides a timber trestle.

The total effective head at the power house is 446 ft. The water is delivered into two receivers, buried in the ground, one on either side of the power house (Fig. 1). The two water-wheels are 59 ins. in diameter, and have each forty-five bronze brackets cast into one solid piece; fourteen of these, when the nozzle parts are all open, receive the water at the same instant. Each wheel has a capacity of 1200 HP at 300 r. p. m.

The generators used in this plant are of the General Electric Company's three-phase type, with twenty-four poles and at 300 r. p. m., have an output of 750 KW at 2300 volts and a frequency of 60 cycles per second. The factory tests show that the variation in volts will be less than 5 per cent. with a constant speed, should the full non-inductive load be thrown off or on.

The cable connecting each generator to its respective panel on the generator switch-board is a three-wire concentric 250,000 CM lead-covered cable, and the exciting wires are a two-wire concentric No. 4 B. & S. lead-covered cable.

The exciters used on this plant are G. E. six-pole, 500 volt machines, and will give 100 KW at 550 r. p. m. Each of these machines is ample for the entire exciting current that will be needed for the ten 750-KW alternators to be put in, and they are each direct-connected to a 135-HP Knight water wheel, similar to the 1200-HP water-wheels previously described. These exciter water-wheels are cross-connected to each receiver, so that either exciter can be operated from either receiver.

The generator switch-board consists of seven marble panels; five for the alternators, one for the exciter and one for the instrument panel.

From the generator switch-board the current is carried to the distributing board by copper bars, of which there are two sets of three, connecting the two sets of bus-bars on the generator board with the two sets of bus-bars on the primary panels of the distributing boards.

Back of this distributing switch-board are nine 250-KW air-blast step-up transformers, the lightning arresters, and the two blowers for cooling the transformers.

Back of the distributing switch-board and on a raised platform are placed the step-up transformers. These transformers raise the potential of the current from 2300 to 16,100 volts, at which pressure it passes to the long-distance transmission lines. The transformers are connected up in sets of three, the delta connection being used on both sides. At each end of the building in the gallery are placed the two blowers, direct-connected to a $2\frac{1}{2}$-HP, 500-volt direct-current motor. These blowers are used in cooling the step-up transformers, and force the air up to the bottom of the transformers, around the coils and out at the top.

The transmission line is calculated to deliver about 3000 HP at the sub-station in Salt Lake City, distance about 38 miles, and consists of two circuits, making six wires of No. 1 B. & S. gauge.

The current is fed into the transmission line at the power plant at 16,100 volts and delivered to the step-down transformers at 13,800 volts. This will give an energy loss of about 10 per cent. in the line, and a po-

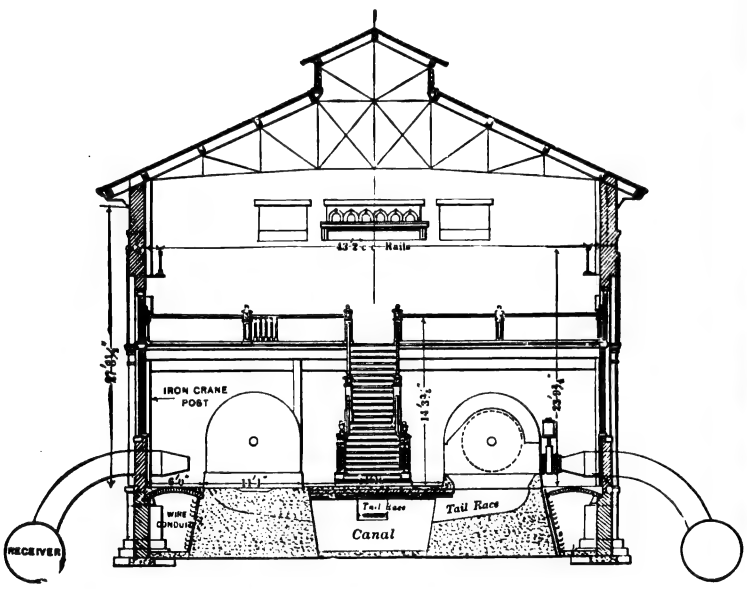


FIG. 1.—EXTERIOR OF POWER HOUSE.

FIG. 2.—THE PIPE LINE ALONG THE SIDE OF THE CANYON.

tential loss of about 14 per cent. The substation step-down transformers deliver this current to the local distributing lines again at 2300 volts. There are at present nine 250-KW step-down transformers at the substation connected by the step-up transformers, and the switch-board in the substation is similar in every respect to the distributing board in the power plant gallery. The cooling apparatus here is also identical with that used in the power plant, except that the motors used are 60-cycle induction motors.

While the transmission lines are at present capable of delivering 3000 HP at the substation, with a 10 per cent. energy loss, if it should become necessary, the step-up transformers can deliver more than this by changing three wires on their high-pressure side, and delivering the current into the transmission lines at 27,000 volts. Thus the line capacity would be more than doubled.

The present installation of the power plant is capable of delivering 3750 KW to its lines, but ample provision has been made to increase this amount to 7500 KW by installing five more 750-KW machines, as new industries or manufactures spring up as the result of the advantages offered to them in Ogden and Salt Lake City.

The current will be used to drive factories, running electric railways from Ogden to Salt Lake City, to the Lake, to Hot Springs and to light the towns and cities in the north of the state. The surplus water in the storage reservoir will be utilized to irrigate large tracts of land in the vicinity.

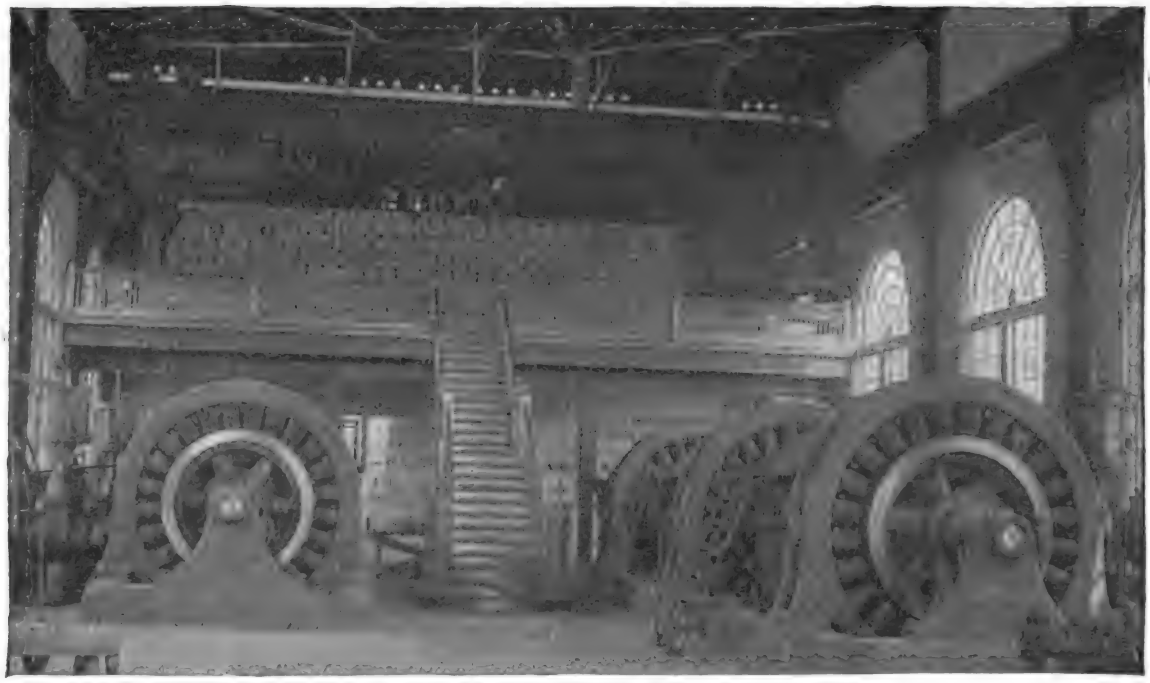


FIG. 3.—INTERIOR OF POWER HOUSE.

Liquid Air.—In the Boston *Herald* of July 1, Prof. Elihu Thomson calls attention to some of the electrical qualities of liquid air, and suggests that the excess of power of large water power plants might be utilized in its manufacture. It has recently been found that liquid air is one of the most perfect insulators, and that most insulating materials cooled to the temperature of liquid air are greatly improved in insulating qualities. It is known, also, that cooling renders it more difficult to cause a spark to occur between oppositely-electrified conductors, the striking distance for a given pressure being diminished. The stability of liquid air, even when open to the ordinary atmosphere is simply dependent upon the heat insulator provided. A suggestion for heat insulation is offered, and it is shown that the present losses of 10 to 15 per cent. in long-distance transmission lines might be reduced to 1 to 2 per cent., by the use of liquid air—with 10,000 HP, this producing a saving of from 1000 to 1500 HP. Moreover, a much higher voltage might be reached than at present with conductors insulated by liquid air—50,000 volts, perhaps, instead of the present 10,000 or 20,000 volts, thus giving rise to a still greater saving. A transformer in liquid air might be made entirely of copper without iron, and its light-load efficiency thus made nearly equal to full-load efficiency. In conclusion Prof. Thomson says that it is too early to make any predictions or calculations concerning this subject. "It must be confessed that it has a certain fascination. Perfection of heat insulation seems to be the key to the situation. All else seems to depend on that, the main questions being what it will cost in power and machinery to supply the necessary evaporation waste in a system of the kind outlined, and whether the voltage of transmission can be raised in consequence of the new conditions."

PERSONAL.

Mr. John McGhie, press representative of the General Electric Company, has gone abroad for a sh rt visit to England and France.

Mr. Richard Varley, of the Varley Duplex Magnet Company, sailed Saturday July 17, for England to spend two weeks with the English Varley Duplex Magnet Syndicate, a company incorporated in England for $50,000 to manufacture duplex magnets similar to the line of work made by the American Company. The English company will also either manufacture or sell the duplex magnet in England, France and Sweden. We understand that the English company is incorporated to make duplex magnets in England to save the cost of transportation from America.

NEW BOOK.

BEARINGS AND LUBRICATION. A Handbook for Every User of Machinery. By A. J. Wallis-Taylor. New York: D. Van Nostrand Company. 208 pages. 75 illustrations. Price, $1.50.

The contents of this volume deal with friction, bearings, stuffing boxes and packings, and lubrication. Friction is treated in a preliminary chapter. The chapter following on bearings discusses the materials employed and gives much practical information on methods of babbitting; many different forms of bearings are described, no less than 27 being illustrated. Chapter III goes thoroughly into stuffing boxes and packings, of which many varieties are described. The remaining chapters are on lubrication, the action of oils on metal, determination of the lubricating value of oils, the adulteration of oils, types of lubricators, storage of oil, cans, etc. The book is one which should prove of much value to those having to do with the subjects of which it treats.

TRADE PUBLICATIONS.

Telephones. The Farr Telephone & Construction Supply Company, 342 Dearborn Street, Chicago, has issued an 84-page catalogue and hand-book of information on telephones, telephone supplies and house goods. A number of diagrams of telephone circuits, and data of various kinds, including a bill of material for an exchange of fifty telephones.

Telephones. The Mianus Electric Company, Mianus, Conn., has issued a 32-page, profusely illustrated catalogue devoted to telephones, house supplies and amateur apparatus. Among the latter are a number of small dynamos and motors and several types of gas and gasoline engines, all of which are supplied finished, or the parts only for assembly by the purchaser.

Fuel Economy. In an artistically cloth-bound volume the Fuel Economizer Company, of Matteawan, N. Y., describes and illustrates in profuse detail the well known Green's fuel economizer for steam boilers, which has been installed on more than 150,000 boilers. A colored frontispiece shows the economizer as arranged in place, and numerous other illustrations show details and give arrangements for various types of boilers and settings.

Circuit Breakers. The Cutter Electrical & Manufacturing Company, Philadelphia, has issued an engineer's edition of its catalogue and data book of the I-T-E automatic circuit breaker, and C-S switches. All the different types are described and illustrated, and full detailed information given for the installation of the apparatus. The pamphlet is handsomely gotten up and contains a number of blank pages of cross-section paper for notes.

Correspondence Schools. The Colliery Engineer Company, of Scranton, Pa., in a 112-page octavo pamphlet sets forth the advantages of the methods of the International Correspondence Schools, and outlines in full detail the course in electrical engineering, and electric power and lighting. The pamphlet also gives extracts from instruction papers to illustrate the system of teaching. Another recent publication from the same source contains 1000 testimonials from students who have followed one or more of the several courses taught.

Dry Steam. A well printed and illustrated 48-page pamphlet has been issued by the Goubert Manufacturing Company, 16 Church Street, New York, of which the Stratton separator forms the subject.

Many excellent illustrations of the Stratton separator are given, showing it in detail and as installed on a number of important plants. The pamphlet contains much information of technical value on dry steam, opening with a treatise on that subject in which all of the principles applying are discussed. "Dry Steam" (the title of the pamphlet) should be on the desk of every steam user.

Gas Engines. In a very handsomely printed and illustrated pamphlet the Westinghouse Machine Company, of Pittsburgh, Pa., describes its new type of gas engine, the accompanying illustrations being Bartlett engravings. This type is the latest development in gas engines, there being an impulse at every revolution, the charge being graduated by means of a sensitive governor in proportion to the load. In appearance the machine much resembles the well-known Westinghouse steam engine. One view shows an engine direct-connected to a dynamo, the smoothness and steadiness of this type permitting such direct connection.

Bullock Bulletins. Bulletin No. 25 of the Bullock Electric Manufacturing Company, Cincinnati, and St. Paul Building, New York, is devoted to multipolar generators and motors for direct-current lighting and power, of which a number of types are shown in excellent cuts. Bulletin No. 27 has for its subject direct-connected, slow-speed motors applicable to all sizes of machine tools and other machinery. Among the applications illustrated are a direct connection to a shaper, lathe and laundry machine. Copies of these well-illustrated and instructive bulletins will upon application be forwarded to our readers.

Steam Apparatus. The A. A. Griffing Iron Company, 66 enter Street, New York, has just issued an even half-dozen of pamphlets, describing a number of its steam specialties. The pamphlets, which are well illustrated and printed, are bound in artistic covers of delicate colors, with artistically designed titles. The subjects of the different pamphlets are steam and water heaters, low-water alarms and exhaust heads, automatic gravity pumps, steam traps and improved feed-water heaters. As all of the apparatus are illustrated in detail, with well-written accompanying descriptions, these handsome publications will be found to contain much to interest the steam user.

Incandescent Lamps. The complexity of incandescent lamp manufacture—at least, as far as relates to the large number of styles that the market demands—is well shown in a recent catologue of the Beacon Lamp Company, of New Brunswick, N. J. More than forty different styles and shapes of lamps are illustrated, ranging from 500 to ½CP. There are standard lamps with curled, straight, multiple and anchored filaments; of high and low candle-power; and in ordinary, spherical, bung-hole, candelabra and other bulbs. In addition there are series, railway, light-house, decorative, surgical and dental lantern and battery lamps. Two forms of Crookes tubes are also shown, and a line of copper-tipped fuse-links.

Electromagnets. Electromagnets of every shape, size and for every purpose form the subject of a catalogue recently issued by the Varley Duplex Magnet Company, 138 Seventh Street, Jersey City, N. J. The Varley electromagnet, as is well known, is made by winding simultaneously a wound and bare wire, thin onion-skin or rope-fringed paper separating the layers. By this means many extra turns are obtained by reason of half the insulation being dispensed with, making the completed electromagnet both smaller and cheaper than the ordinary form. Several plates show many different forms of magnets for special purposes, some of which are little known. Bobbins and coils for Ruhmkorff or induction coils are also listed, thus enabling the maker of such an apparatus to dispense with the most troublesome work of winding.

Switches. The Western Electric Company, of Chicago, has just issued a complete catalogue of its E, EE and Q switches, which is a most creditable specimen of the printer's and engraver's art. The different sized switches are described by numbers with their capacity in amperes, and all the dimensions of the switches are plainly given in tables so that it is possible to drill switch-boards before the switches are received with the assurance that the switches will fit when they are placed in position. A cut and catalogue number of every switch part is given, to facilitate the ordering of small parts at any future time, a catalogue number and cut of every switch part is given. Special switches are made for 500 volts, and the Q switches, which represent the quick-break type, are made in all sizes from 25 amperes up. There is also shown in the catalogue the latest design of the round type Ellicott voltmeter switch, the "V" changing switch, and the switch-board spring-jacks, plugs and cords. A copy of this catalogue will be sent upon application.

BUSINESS NEWS.

The Minneapolis Electric Company, 13 South Fourth Street, Minneapolis, Minn., reports a very brisk demand for its wire reel and meter. This reel is a combination for reeling and measuring wire, and that it is a very efficient device in every respect for this purpose is attested by the numerous commendatory testimonials its makers have received.

O. S. Platt & Company, Bridgeport, Conn., which recently introduced a new double-pole flush switch that has met with very satisfactory sales, has found that there was a demand for a low-priced but serviceable push-button flush switch, and has just put on the market a switch of original design and simple mechanical construction, which seems to fully meet these requirements.

Voltage Regulator. The Belknap Motor Company, Portland, Me., has recently received orders for its voltage regulator from the following companies: Mt. Morris Electric Light Company, New York City; Electrical Engineering Company, San Francisco, Cal.; Knoxville Electric Light Company, Knoxville, Tenn.; United States Electric Light Company, Washington, D. C.; Potomac Electric Light & Power Company, Washington, D. C.; Redwood Mills Company, Redwood, Minn.; F. Mercier, Princeton, Me., and D. E. Stearns, Skyuka, N. C.

I. T. E. Switches. The good fortune that some manufacturers of generating machinery and of underground cables have recently been experiencing through the receipt of huge orders, is being extended in other directions. The Cutter Electrical & Manufacturing Company, of Philadelphia, has been one of the recent recipients, its business lately having so largely increased that the president of the company, Mr. H. B. Cutter, had to forego the pleasure of an intended trip abroad, owing to the demands recently made at home on his attention.

Push-Button Switch. The F. & L. flush push-button switch is the latest specialty of the Electric Appliance Company, Chicago. This switch is a very simple and compact device, the size of the face plate being no larger than an ordinary two-button gas key. The face plate is nickel-plated, with pearl buttons. One of the merits of the switch is the ease with which it is operated. It is also a less expensive switch to make than any first-class push-button switch heretofore offered. It is at present made only in single-pole style, with a capacity of 5 amperes, although other sizes and capacities are now in preparation.

The Central Electric Company, Chicago, is constantly adding to its already large line of specialties, and is very much gratified by its constantly increasing railway trade. It is making some very pleasing shipments to foreign countries, and its line of railway material is meeting with the approval of railway companies. It is Western agent for the Bound Brook trolley bushing and motor bearings, and carries a complete stock of all railway materials. It is also Western agent for the Pittsburgh trolley pole, and carries a complete stock of the same. It is also representative for the Nelson insulated adjustable and rigid cross-overs, of which it is furnishing large numbers throughout the country.

Rawhide Goods. The Chicago Rawhide Manufacturing Company, Chicago, reports that of late there has been a very satisfactory increase in its business. At present the company has all the orders from London that it can fill during the next two months in connection with its business in this country. This company is the pioneer in the manufacture of rawhide goods of all kinds, its specialty being rawhide dynamo belting and gears and pinions for motors and dynamos. The pinion made by this company is in great demand among manufacturers and users of dynamos and motors because of its durability and the fact that it is noiseless. The company also manufactures rawhide bell and fare-register cords.

Waste-Oil Filters. The "Famous" automatic waste-oil refiner and purifier has displaced all of the various waste-oil filters in the following important run plants, during the past month. In St. Louis: The St. Louis Exposition, 20 gals.; Home Brewery, 5 gals.; Drummond Tobacco Company, 10 gals.; St. Louis Automatic Refrigerating Company, 5 gals.; Liggett & Meyers Tobacco Company, 40 gals.; Lindell Railway Company, power house No. 17, 40 gals., and power house No. 2, 75 gals.; Century Building, 10 gals.; Security Building, 5 gals.; Columbia Brewery, 10 gals.; Southern Electric Company, 10 gals.; Huse & Loomis Ice Plant, 5 gals. Electric Light Plant, Dexter, Mo., 10 gals.; Syracuse Rapid Transit Rrilway Company, Syracuse, N. Y., 75 gals.; Manchester Electric Light Company, Manchester, N.H., 40 gals.

Electrical Evidence. Recently the storage battery and miniature lamp played an important part in a damage suit at Chicago. A large six-story apartment building, on Michigan Avenue, should, according to plans and specifications, have had its twenty-three flues lined with tile, or flue lining. From an examination of the interior of the flues, by means of two 8-CP, 16-volt lamps, connected to a small 15-ampere-hour Haschke storage cell by a long cable, lowered from the roof, it was found that all the twenty-three flues had only from one to three sections of lining in them, extending from the top downwards. The absence of the lining caused the smoke to enter the rooms through the walls and led to great damage. Damages were allowed on this showing, and the entire twenty-three flues will have to be removed and rebuilt, at a cost of about $3500.

A Few Electrical Don'ts. The Buffalo Electric Company, in a circular under this caption, contains a great deal of hard sense, and gives the following advice, which might well be followed with profit: "Don't try to revolutionize the electrical business by cutting prices. You can't. Don't expect to get all the jobs you figure on and get mad if you don't. Don't expect to make a living on a 10 per cent margin of profit. You can't. Don't abuse your competitor because he underbids you; he may lose money and yet do as good work as you. Don't bid low, do poor work and employ boys to even up. You can't. Don't eucate the embryod electrician and then try to kill him off as soon as he is able to work. Don't fail to keep your credit good. You must get a fair price for your work or you can't. Don't, with a big D, think you are the whole push. There are others. Don't give your work away; what is worth doing is worth getting paid for; and above all employ good workmen. Watch the don'ts if you wish to succeed."

The Engine Trade. There are kindred lines of industry which, although not called by the name electrical, certainly have a close connection. Among these might be mentioned the manufacture of automatic engines, which are used for electric purposes. Prosperity or adversity is reflected from one to the other of these industries. When, therefore, we learn that large works like the Ball Engine Company, Erie, Pa., who build the high grade Ball automatic engine exclusively for electrical purposes, are full of orders, we infer at the same time that the strictly electrical interests are improving. Among orders recently received are the following: From the Chesapeake & Ohio Railroad, two 75-HP engines for electrical purposes; one of these engines is direct-connected to a generator, and both will be used at Newport News, Va. From the Mt. Washington Electric Light & Power Company, Mt. Washington, Md., which has recently increased the capacity of its station by adding a 100-HP engine, being the third engine of this manufacture now in the station; from the Mount Vernon Company, Woodberry, Md., a 100-HP engine, being the second order for this make of engine; from the Sterling Varnish Company, of Pittsburgh, Pa., a 75-HP engine for electrical purposes.

Storage Batteries. It is a significant fact that the largest users of storage batteries are those who have given the subject of their manufacture and application the greatest amount of study. Four of the Edison Companies equipped with chloride accumulators, have contracted for duplicate plants—those at New York, Brooklyn, Boston (three installations) and Lawrence, Mass. About a year ago a battery of chloride accumulators was installed in the New York custom house for the purpose of furnishing current for twelve hours per day when the dynamos were shut down. A contract has just been closed

by the Electric Storage Battery Company, of Philadelphia, for a second plant to be installed in the same building, to be used for maintaining the night lamps in the sub-treasury and assay office. Other contracts recently closed cover batteries of chloride accumulators for the San Francisco Gas & Electric Company, the Criminal Court Building, the Commercial Cable Building, the Queens Insurance Building, New York; the State Mutual Assurance Company's new building at Worcester, Mass.; and Messrs. Smith & Wesson, Springfield, Mass. The installation of two batteries of large capacities has just been completed for the Consolidated Traction Company, of Pittsburgh, where they are used for regulation and maintaining the potential on its trolley lines; and the Barre & Montpelier (Vt.) Railway Company has just contracted for a battery for regulation. The Postal Telegraph & Cable Company is installing chloride accumulators in its offices at Albuquerque, New Mexico, and El Paso, Tex. Among the yachts that have been equipped with chloride accumulators this year are the Embla, Sapphire, Alicia, Clermont, New Hiawatha, Raynham, Marietta, Althea, Punjaub, Satanella.

Consolidation of A. K. Warren & Company and the Electrical Maintenance Company. The well known houses of A. K. Warren & Company, of 451 Greenwich Street, New York City, and the Electrical Maintenance Company, late of 50 Broadway, have consolidated their interests into one business and formed a substantial concern with branches in Boston, Philadelphia and Baltimore. The large trade which was heretofore profitably enjoyed by A. K. Warren & Company, is now augmented by between 500 and 600 maintenance contracts, transferred by the Electrical Maintenance Company on consolidation. It was wisely decided by the various heads of the two companies interested that a change of name would be beneficial, and the consolidated concerns will be known as the American Electrical & Maintenance Company, retaining as a trade mark the well known white Swiss cross adopted by the first-mentioned firm some years ago. The field of the business established by these two companies covers maintenance by contract, repairs in general and emergency work in particular, and wiring supplies of every description; so that after a contractor has installed a plant, wheresoever, by contract with this firm, a certain expense per annum is guaranteed by a contract with this concern to cover all losses by damage, both large and small, to the installation. The directors and stockholders of the American Electrical & Maintenance Company are men well known in the electrical business, and can assure their patrons prompt attention to all calls made upon them. The engineering department is under the superintendence of Mr. A. K. Warren, whose ability and indefatigable zeal in emergency matters are well known at most of the electric light stations and isolated plants within 100 miles of New York. The financial part of the business is conducted by Mr. James Rich Steers, formerly Mr. Warren's partner in the firm of A. K. Warren & Company, and the entire general management of the enterprise is in the hands of Mr. George Stanmore, late general manager of the same firm. The Board of Directors consists of Messrs. A. K. Warren, E. R. Johnes, G. Harvey Cook, Henry B. Wilson, Wm. Duryea, J. R. Steers, George Stanmore, of New York, and Henry A. Root and G. Arthur Hilton, of Boston. The home office of the new firm is at 451-3 Greenwich Street, New York City. The origin of this business dates about five years ago in a small shop employing about five men. It has now a payroll list of about 120 men on repair and emergency work alone.

LA CROSSE CONVENTION NOTES.

Mr. W. Worth Bean, of St. Joseph, "rose to the occasion" frequently during the session.

Mr. Tom Ferris, of Milwaukee, took good care of the General Electric Company's customers at the convention.

Mr. Geo. Cutter, of Chicago, was here, there and everywhere, and was, in fact, not a small part of the convention.

Mr. Jas. Wolf, of Chicago, in his usual genial manner, kept the New York Insulated Wire Company's products well in evidence.

The Bryan-Marsh Company had that energetic salesman and all-around good fellow, Mr. Jos. M. Hill, of Chicago, in charge of its display, which was Mr. Hill himself.

Mr. Thos. R. Mercein, of Milwaukee, not only acted as secretary, but was a host in himself. The delegates to the Northwestern Association would feel like cats in a strange garret if Tom Mercein failed to attend.

The Crouse-Tremaine Carbon Company, of Fostoria, O., was ably represented by Mr. Jno. S. Maurer, who neglected no opportunity to expatiate upon the merits of the Crouse-Tremaine carbons, and whose motto was, "The best carbon is always the cheapest."

Benton & McDonald, of La Crosse, manufacturers of electric light and power machinery, did not exhibit at the hall, but instead opened their factory to the delegates, many of whom took advantage of the opportunity. This company makes a specialty of search-lights and reports the past month's business as one of the best in its history.

The Electric Appliance Company, of Chicago, gave a souvenir of its soldering paste, and also showed a line of the American Electric Heating Corporation's apparatus, consisting of sad iron, soldering iron, and the new guard water-proof receptacle, the latter being shown in actual operation in a jar of water. The representatives were Mr. W. W. Low and Mr. Frank McMasters.

The Sawyer-Man Electric Company, of Chicago, was represented by Mr. C. A. Ross. The principal feature of the exhibit was the 220-volt, glass-bridge lamps. This glass bridge prevents short circuiting, which has heretofore been the objectionable feature of high-voltage lamps. A full line of other types of lamps was exhibited, both plain, fancy and colored, of various sizes and voltages.

The Central Electric Company, of Chicago, was represented by Mr. W. P. Upham, who had charge of the exhibit, which consisted principally of overhead material of its own manufacture. Naturally Okonite wires predominated and along with Lundell fan motors made a strong bid for favor among the delegates. These high-quality goods have established for the Central Electric Company, a reputation second to none. Mr. Chas. Burton was also on hand.

The American Electric Heating Corporation had in operation a curling-iron heater using .4 amp, a 4 lb. sad iron, using 1½ amp; a 6½ lb. sad iron using 4 amp.; a 4 in. disk stove using 2 amp.. a 4 in. aluminum stewpan using 2 amp.; also a 5-o'clock-tea kettle, an immersion coil and a universal enameled rheostat, being one of the latest rheostats for fuel regulators or motor starters. Mr. F. P. Luther, western manager, of Chicago, was the sole representative.

The Columbia Lamp Company, of St. Louis, Mo., was represented by Secretary and Treasurer A. C. Garrison, who displayed several different samples of his company's product. In addition to the lamps, the liquid matter from which the filaments are made was shown, and also the threads b fore and after carbonization. A handsome souvenir button, showing the company's factory, was distributed. Judging from the many buttons worn by delegates, Mr. Garrison certainly kept things thoroughly warm for the Columbia Company.

The Electrical Supply Company, of Madison, had on exhibition a full line of specialties, among which were Grimshaw and Raven core wire, Columbia lamps, Standard telephones, American Toy & Marble Company's lines of tubes and insulators, and many other specialties, principally central station supplies. From the energetic manner in which Mr. Burch button-holed central station men and the attention he received from them, it is quite probable that he has several orders at his belt. This company is about to issue a 250-page catalogue, containing a special index not given in other publications, which will make it of unusual value on account of the facility offered in finding any desired article. This company was represented by Mr. L. W. Burch, president, and Mr. H. C. Hackney.

The Wagner Electric Manufacturing Company, St. Louis, as is usual, had something new in the shape of a station instrument mounted on marble slabs, showing the manner of connecting to the switchboard. It also exhibited a line of transformers, a five-horse alternating current, single phase, induction motor, and a three-horse 110-volt D. C. motor. It also had a single-phase alternating-current ceiling fan in operation, and in addition exhibited a set of photos of switch-boards, showing the latest designs for alternating-current, high-potential, multi-phase distribution and street railway and power switch-boards. A very neat souvenir was distributed by this company in the form of a button showing a cut of the company's office and factories. The representatives were Mr. A. H. Abadie, from St. Louis, and Mr. H. L. Foster, from Chicago.

The Pacific Electric Company, exhibited a fine line of Espersen adjustable shade lamps, and the Espersen dental and surgical lamps, including also such special lamps, as those used in the examination of the eye, nose and throat. These lamps are easily adjustable to any position, and on account of their simple construction, and mechanical perfection, they appeal strongly to the lighting public. They are made in ten different styles, and the enameled lamps are made in colors to match surroundings or furnishings. The standard color is green enamel finish inside which gives a high degree of reflection and at the same time the invariable protection to the eye makes them very valuable in surgery and dental work. The exhibit was one of the handsomest and neatest at the convention. The representatives present were Mr. W. W. Withee, secretary; Mr. N. H. Withee, president, and Mr. A. F. Espersen, vice-president and manager.

The Westinghouse Electric Manufacturing Company, exhibited a 5-HP shunt motor, multipolar type; 200-ampere circuit breaker; Wurt lightning arresters, both of the non-arcing metal and non-arcing railway types. It showed also a type of line and station arresters, a Shallenberger amperemeter and integrating wattmeter, which latter accurately measures inductive loads and is especially designed for motor work. It is guaranteed to start on one-half of 1 per cent. of its full load current. The central station type of transformer on which Prof. Stine, of Armour Institute, has just completed tests, and found the efficiency and regulation to be unsurpassed, was also on exhibition. A constant potential A. C. arc lamp for 7200 alternations attracted considerable attention and interest, and called forth much favorable comment, because it operated without any perceptible humming. Mr. Henry Floy, the Chicago agent, was the sole representative Lamps, meters, etc., were shown in operation.

The General Electric Company's exhibit consisted of a full line of Thomson recording wattmeters, showing some of the latest inventions along this line. A wattmeter to be used on street cars is claimed to fill a long-felt want in the electric railway field, inasmuch as it places the manager of a street railway system in possession of data, as regards the running of individual cars on the different portions of the system. The other meters shown were the well known types, for 100 volts alternating or direct, 220 volts for two 3-wire systems, and a 500-volt instrument for power circuits. The measuring instruments were complete and unique in themselves as all parts of lighting and power stations are taken care of by switch-board, portable and pocket testing instruments. The type H transformer was displayed in a small form in detail. Three types of lamps were exhibited. The standard lamp is simple in design, simpler in mechanism and durably constructed, having a high economy with an extra long life. The other two lamps on exhibition are of the single solenoid 5 and 3-ampere type for direct current. One of the principal features on exhibition was a Wirt lightning arrester. This arrester was selected under severe competition at Niagara Falls to take care of the high-potential current there generated and distributed throughout that vicinity and Buffalo. Mr. B. E. Sunny, the Western manager, was present; also Mr. F. N. Boyer, Mr. Thos. Ferris and Mr. R. A. Swain.

B. & O. Improvements.

A stone wall almost a mile in length with an average height of 18 ft., has been built along Second Avenue in Pittsburgh, by the Baltimore & Ohio Railroad Company. This is part of the half million dollar improvement that the company is making at that point.

Every passenger coach, baggage car, parlor car and dining car of the Royal Blue Line, between Washington and New York, has been repainted and refurnished during the past six months.

American Electrician.

Vol. IX. New York, September, 1897. No. 9.

A GERMAN THREE-PHASE CENTRAL STATION.

ONE of the first of the larger city plants for the industrial distribution of energy by means of the three-phase current is that of Strassburg, Germany, recently installed by the Allgemeine Electricitäts Gesellschaft, of Berlin.

This company, as is well known, was the first to demonstrate, by the Lauffen-Frankfort transmission, the practicability of three-phase currents for the distribution of energy over distances that were hitherto regarded as insurmountable. The results then obtained tended strongly to encourage, from a technical point of view, the installation of central stations for three-phase currents. For example, besides numerous plants like those of Madgeburgh, Plauen, Meinel Delta, etc., there have been installed the more considerable plants at Rheinfelden, Upper Silesia and Oberspoll; these are gradually to be enlarged to a capacity of 50,000 HP, and are intended more especially for power purposes. The plant at Oberspoll is designed to supply, in connection with a second central station in the west of Berlin, a power service extending in a wide compass around the imperial capital.

The original plan for the Strassburg central station was prepared by Oscar Von Miller, of Munich, and was based upon the employment of simple alternating currents, but on undertaking the installation, the Allgemeine Electricitäts Gesellschaft substituted the three-phase system. Owing to the fact that the supply of energy from central stations for power service is coming more and more into the foreground; this substitution was resorted to principally with a view to the use of induction motors, which possess the advantage of simple construction, of not requiring brushes and sliding contacts and of starting under load.

The plant was first put in operation in May, 1895. In anticipation of a total consumption corresponding to 2250 KW, it was provisionally supplied with a generator capacity aggregating 1600 HP. In the second year after its installation, however, it became necessary to enlarge the plant and to provide space for 5000 HP to 6000 HP, additional buildings being added for this purpose.

The three-phase currents are generated at a voltage of 2750, which is transformed down to 120 volts at the feeding points. Of the total amount of power above mentioned, 800 to 1000 HP in the form of a 500-volt direct current is to be utilized for electric railway purposes. A storage battery of 370 to 515 ampere-hours capacity is employed as an auxiliary. The central station and the

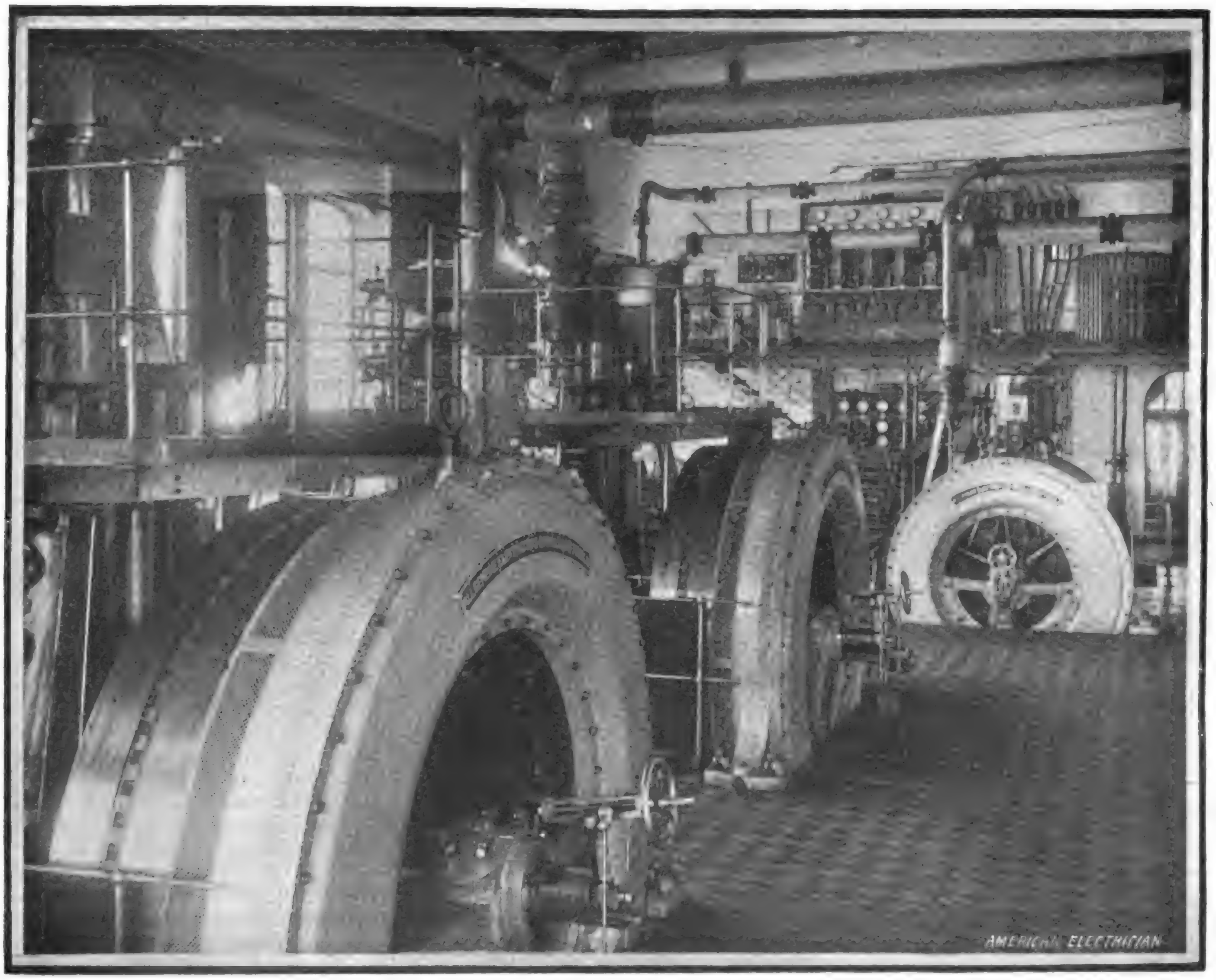


FIG. 1.—GENERATING ROOM, STRASSBURG CENTRAL STATION.

system of distribution will first be taken up, and finally a few words will be added concerning the electric railway generators.

The Central Station.—The central station is situated on the harbor within the walls of the fortification, at the point where the Ill River enters the city.

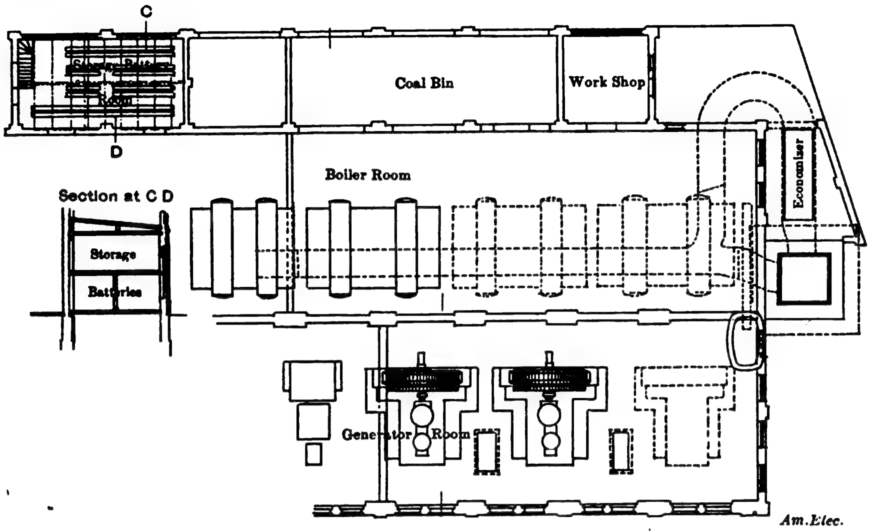


FIG. 2.—ORIGINAL PLAN OF STATION.

This situation is a favorable one, not only on account of the ease with which water for feed and condensation is obtained from the nearby river, but also because of the coal supply, which is transported over a connecting track directly from the railway line to the coal bins. The ground on which the station stands covers an area of 6000 sq. yds. The buildings, shown in Figs. 2-6 contain all the departments, from the generator room and coal depots to the workshop, testing laboratory, offices and dwellings of the employes. The boiler house (Fig. 2) was originally designed for the reception of six boilers, its ground dimensions being 72 ft. × 41 ft.; when the building was completed, however, it was enlarged to a total of 178 ft. × 41 ft. At first four tubular boilers of the Steinmüller type of 2450 sq. ft. heating surface each, were put in, each producing per hour 7480 lbs. of dry steam at 150 lbs. pressure with 8 lbs. of water evaporated for 1 lb. of hard coal of 7500 calorific value.

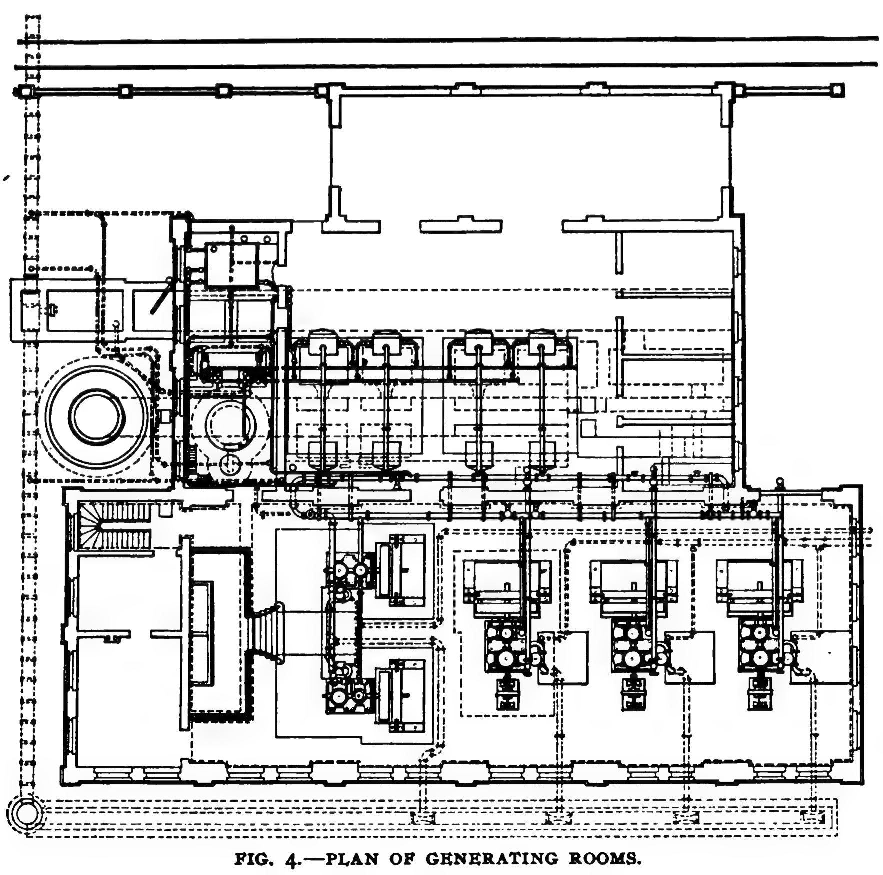


FIG. 4.—PLAN OF GENERATING ROOMS.

Each boiler is fitted with a stop valve and two feed-water valves having long spindles worked from the fire-room floor. Each pair of boilers has a single setting, which is accessible from all sides. A common smoke conduit of 40 sq. ft. section leads beneath the boilers to the chimney, which has a height of 147 ft. and a diameter of 6½ ft. The boiler plant is at present being provisionally increased by two boilers having the same dimensions as those already in place, and by two larger ones of 3260 sq. ft. heating surface each. Space has been reserved for a third pair of boilers. The new boilers communicate with a second chimney 213 ft. in height and 8 ft. 2 ins. inner diameter. In the smoke flue there is an economizer of 2580 sq. ft. heating surface which is sufficient to heat the feed-water, corresponding to about 1000 HP (the power usually required for daily use), to a temperature of 110 degs. to 120 degs. C. This economizer, it may be added, will, as calculation shows, pay for itself in a short time by the consequent economy in fuel. Beneath the floor, in front of the boiler, is the ash conduit, which is readily accessible and connected with an ash hoist on the outside of the building. The feed and condensing water required for the work is led from the Ill to a purifying well with a double removable wire screen and thence to a collecting well from which the condenser draws the necessary condensation water. The condensation having been accomplished, this water is conducted to a second collecting well, of which a part is emptied into the Ill through a cemented escape pipe, while another part is raised by means of pumps into a filter basin. Here it is freed from oil by being made to pass through three chambers filled with fine charcoal. As the water is too hard for direct use as feed, it is first led to a purifier and freed from the contained lime and magnesia salts, as well as from the iron compounds and earthy matter occasionally found in it. The apparatus furnishes 282 cu. ft. of purified water per hour. It is completely self-regulating, so that when the feed is shut off the supply of water, lime and soda solution also ceases automatically, and the loss of reagents is thus prevented.

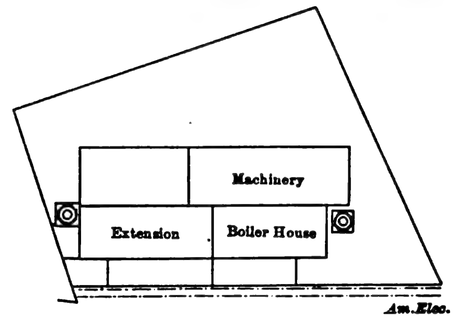
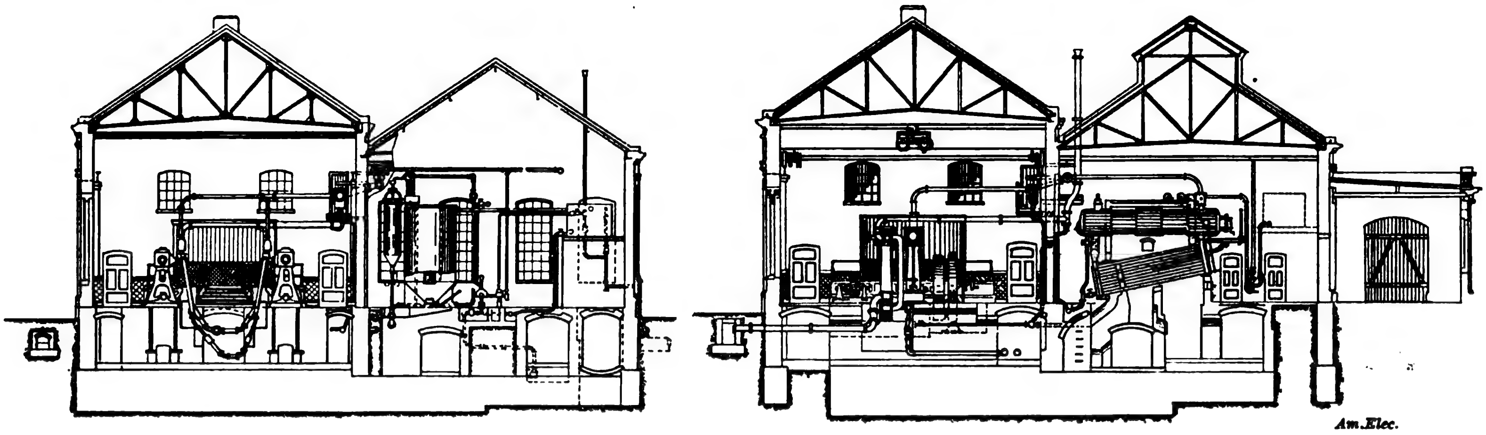


FIG. 3.—GROUND PLAN OF STATION BUILDINGS.

The purified water flows into an elevated reservoir of 350 cu. ft. capacity and thence is drawn by pumps or injectors. When the plant was first built, two quadruple-acting, duplex steam pumps which forced 700 cu. ft. water per hour against 150 lbs. boiler pressure, were sufficient. These pumps are fitted with an automatic pressure regulator and air chamber, so that they either start or stop with the opening or closing of the boiler feed-valves. From the filter basin the pumps draw through a two-way valve the water of condensation which has been freed from oil by filtration, and sends it into the water purifier; or they force the purified water which comes from the reservoir into the boilers through two separate feed-pipes. The exhaust from the pumps is used to heat the feed-water, and for this purpose is led through a copper coil which is in the reservoir. As a reserve, a restarting injector is used which furnishes 107 cu. ft. per hour.

In order to meet any emergencies, the pumps can also send unpurified water directly into the boilers, and in addition, the elevated reservoir is connected with the city water mains.

The purifying apparatus suffices for the



FIGS. 5 AND 6.—SECTIONS OF STATION.

present number of boilers and will also be used in the future during the night hours. The object of this is to provide for a greater reserve in the reservoir for daily requirements.

To meet the demands of the enlarged plant, another large feed pump is being put in, together with a reservoir pump for the water purifier. In order that this may be worked during the night at a time when there is no steam pressure and the storage batteries are taking the current load, the water purifier is to be run by electric power.

The steam from the boilers passes through steam pipes having an internal diameter of 10 ins. This pipe is fitted with valves in such a way as to permit the cutting out of

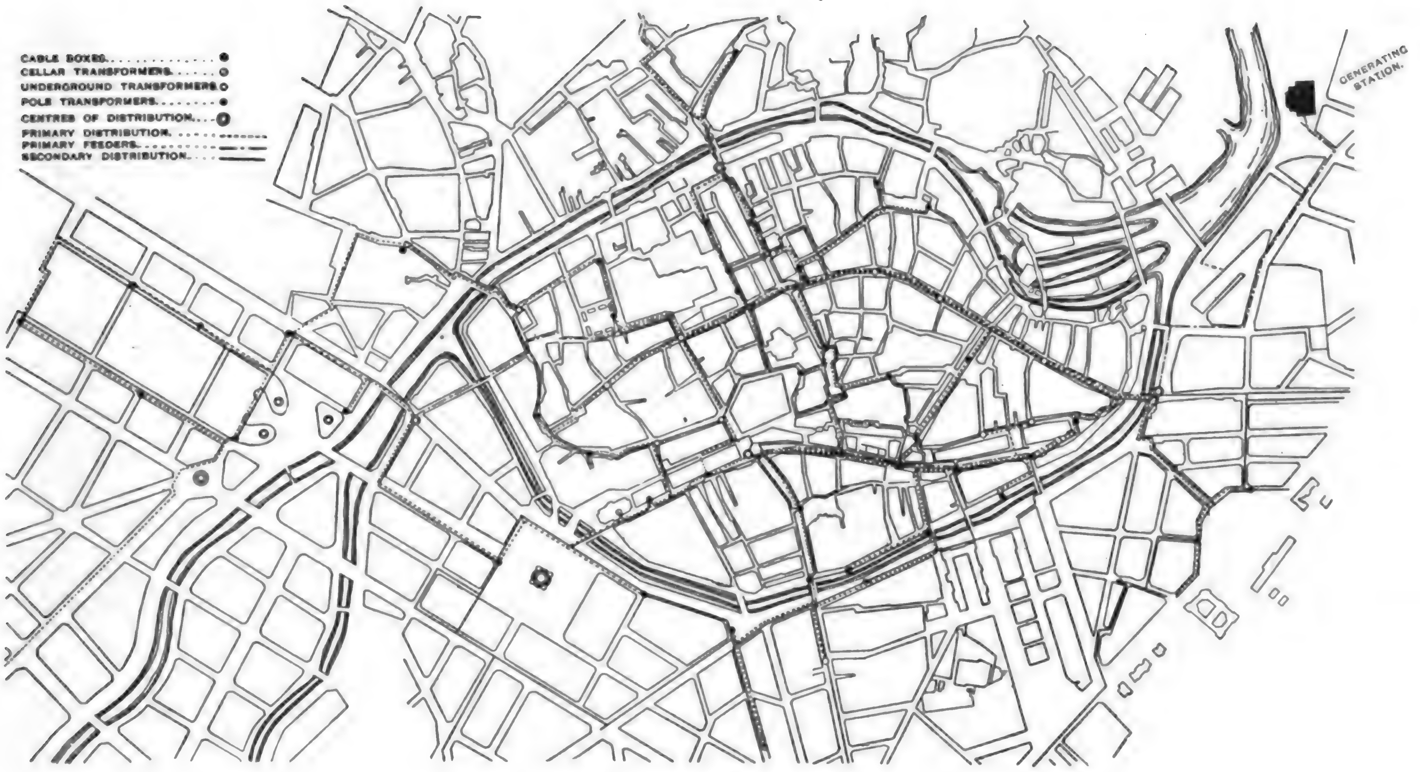


FIG. 7.—PLAN OF DISTRIBUTION.

single sections in case of leakage or other defect. The live-steam pipe system is lagged and freely provided with the necessary valves, cocks, expansion joints, drains, and galleries, for ease in making repairs. They are as easily accessible as the exhaust pipes, which run in walled conduits underground.

Adjoining the boiler house is the coal shed which has a floor area of 78 ft. × 20 ft. Alongside of it runs the railway track for the coal cars, which discharge their contents through large sliding doors.

The Generating Room.—The engine room is built alongside the boiler house, and, as originally constructed, covers an area of 123 ft. × 41 ft. It is being extended at present, however, to a total of 208 ft. × 41 ft. The room is high, spacious and light, and is spanned by a traveling crane having a carrying capacity of 10 tons. Around the walls there is a wainscoating of porcelain tiles, 5 ft. high, and the decoration of the room in general is worthy of the central station of an important city. On the left wall there is a gallery 11.5 ft. high and 16.5 ft. wide for the switch-board, which is approached by a comfortable stairway. The space below the galleries is occupied by the rotary converters. Hitherto power has been generated by two 300-HP and three 400-HP steam engines; to these, three engines of 1125 HP each are to be added. It is intended to still further lengthen the engine room to the limit of the property, with a view to providing space for a fourth engine of this latter size. All engines are vertical compound with jet condensation, and have been built in the workshops of the Alsatian Engine Building Company at Mulhausen. Figs. 4 and 6 show the arrangement of these engines. The 200-HP engines have cylinders of 13.4 and 22 ins. diameter, with a piston stroke of 16.5 ins., and work at 180 r. p. m. under maximum load.

The 400-HP engines have a high-pressure cylinder of 17.3 ins. and a low-pressure cylinder of 28.4 ins., and a speed of 150 r. p. m. The steam pressure at the throttle is 140 lbs. The normal capacity of 150 HP in the smaller and 300 HP in the larger engine is obtained at a cut-off at the high-pressure cylinder of quarter stroke, corresponding to a total expansion ratio of 1 to 12; the maximum capacity, however, of 200 HP and 400 HP respectively is gotten at a cut-off of .35 stroke,

corresponding to a total expansion of 1 to 8. The 400-HP engines have Corliss valve gear, and the 200-HP engines have piston slide valves. The valve mechanism is so constructed that all cut-offs from 0 to .6 can be obtained in the small cylinder.

The governor in use is so arranged as to admit of a convenient change by hand of the speed of the engine, an arrangement which is of great value in connection with three-phased dynamos that are run in parallel.

lbs. pressure at the throttle and .27 cut-off in the high-pressure cylinder, they furnish 850 effective HP and at .35 cut-off they furnish 1150 HP. The revolutions per minute at normal capacity are 107 and can be changed by hand during operation so as to be brought down to 106 at no load and at maximum load be increased to 107. The steam used, including condensation in steam jackets, amounts to 15.4 lbs per HP under normal load, and to 16.5 lbs per HP-hour under maximum load.

On the completion of the plant a considerable change is to be made in the present use of the steam engines. Two of the 400-HP engines are to be connected at one end with large direct-coupled continuous-current dynamos instead of the small exciting dynamos; this is for the purpose of generating energy for the increased street railway traffic. The 400-HP three-phase dynamos that are coupled to the other end will remain in reserve for the generation of current for lighting and motor load. The two 200-HP engines are to be used for the lighting system during the day and night hours of smallest load, and also to form a reserve for the street railway service. The new 1125-HP engines with their three-phased generators, are designed exclusively for lighting and power requirements during the hours of maximum consumption.

The gradations in the size of the three-phase units are, therefore, admirably adapted to the load curve of Strassburg. Ordinarily a 200-HP engine attends to the night work and a 400-HP engine, assisted by a smaller engine in case of need, takes the day load, while toward evening one of the larger engines is thrown in. If the occasion requires it, a second 200-HP engine bridges between.

The gradations from 400 + 200 + 200 = 800 HP to 1125 HP are relatively small, so that they are amply sufficient for advantageous loading of the engines under the different working cond tions. Besides, the smaller number of engines working simultaneously permits a better distribution of the load than would be the case where there are several smaller engines. In the latter case it would be difficult to prevent an extra load on one of the engines; moreover, as is known, with larger engines the cost of the space occupied and of the installation, and the consumption of steam per unit of work for a continuous period, is less than with smaller ones.

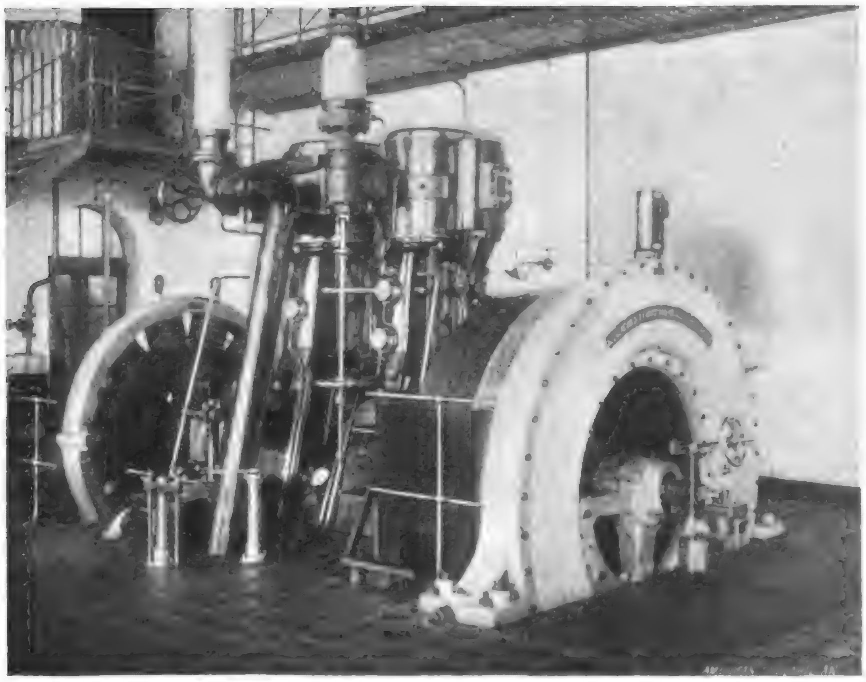


FIG. 8.—GENERATING UNIT.

The fluctuations of speed of the engines on suddenly changing the load from normal to no-load do not exceed 5 per cent., and on 25 per cent. change of load amount at the most to 1½ per cent.

The high- and low-pressure cylinders are fitted with steam jackets, covered with non-conducting lagging enclosed by japanned tin.

All lubricated parts in motion are served by a central oil lubricator, while the cylinders are provided with automatic lubricating outfits. The fly-wheels of the 400-HP engines are fitted with radial, circumferential projections, which form the pole-pieces of the three-phase dynamos. Thus far continuous-current machines have been also direct coupled to the other end, serving as exciters for the three-phase dynamos. The two 200-HP engines also simultaneously drive, at both ends of the shaft, generators for three-phase and continuous currents, of which the latter supplies the street railway. In order to excite these 200-HP, three-phase dynamos, two rotary transformers and a dynamotor are placed under the switch-board gallery. The dynamotor is held in reserve for cases of necessity and can take a current of 500 volts from the street-railway bus-bar and transform it for excitation into a current of 65 volts.

The large steam engines, which are at present being built in view of the enlargement of the plant, are vertical twin engines with jet condensation. The diameters of the cylinders are 25¼ ins. and 45¼ ins., with a common piston stroke of 39¼ ins. At 135

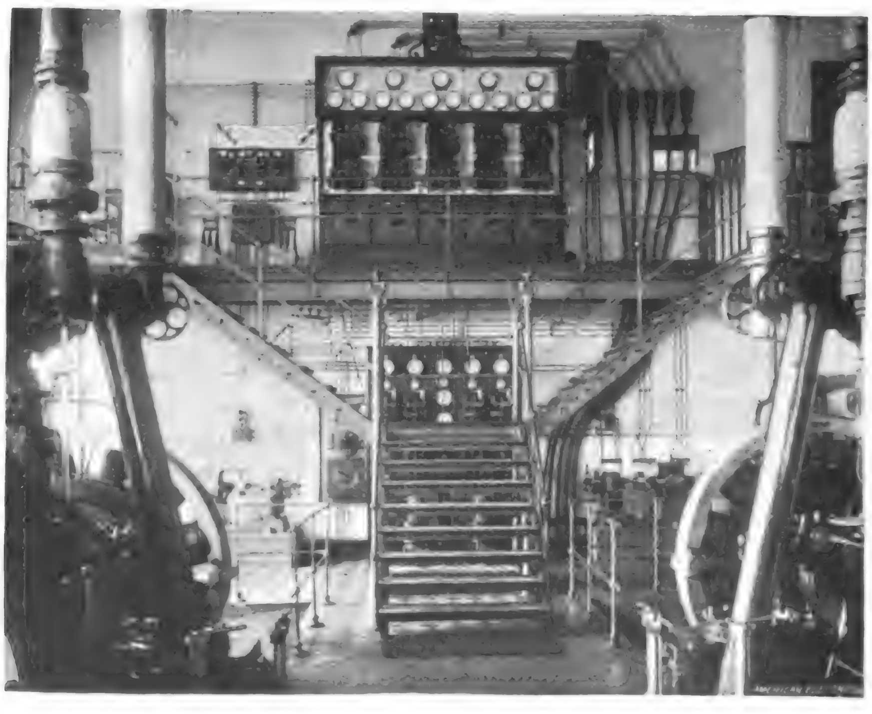


FIG. 9.—SWITCH-BOARD END OF GENERATING ROOM.

The high-pressure cylinder has balanced piston valves and the low-pressure cylinder Corliss valves. On load fluctuations of 25 per cent., the change of speed reaches at the most 1.5 per cent. and on passing from full to no load, or *vice versa*, the change in speed does not exceed 5 per cent., even for an instant. Lubrication is effected by means of a specially designed centrifugal pump.

The Generators.—The three-phase generators have a fixed exciting bobbin and fixed armature coils. The inductors, which are

screwed to the fly-wheel of the steam engine, alone have motion. They change the magnetic flux through the armature core and thus cause a current to be induced in the armature windings. The current is taken from fixed binding posts and led to the bus-bars of the switch-board; brushes or sliding contacts are, of course, not needed. The iron cores of the armature, as well as the inductors, are laminated, being composed of thin plates insulated from each other by paper. The frame, which consists of two pieces, rests on two lateral beams and a separate bottom support, and holds also a pedestal for the outboard-shaft end; the latter can be moved in the direction of the axis in case repairs become necessary. The construction of the machines is simple and compact, as may be seen from the diagrammatic view (Fig. 10). The two three-phase current generators of the 200-HP engines furnish 140 KW at 2750 volts. They have 16 inductor poles and 32 armature poles, and make 187½ r. p. m., which gives a frequency of 100. They are, as has already been said, excited by three 65-volt, continuous, direct-current machines.

The 400-HP three-phase dynamos furnish 280 KW at 2750 volts. They have 20 inductor poles and 40 armature poles and make 150 r. p. m., corresponding to a frequency of 100. Their excitation requires 4 KW or about 1.4 per cent. of their capacity. The watts lost in both armature coils amount to about 2 per cent., and the loss through hysteresis to about 1.3 per cent. The total weight of the iron of the frame, armature and inductor pole-pieces, exclusive of shaft and pedestal, is 19,250 lbs. The weight of copper in the field and armature is about 2000 lbs.—that is, about 5 lbs. per HP. The ampere-turns of an armature coil and the exciting coil bear the proportion of 1 : 15.

The 1125-HP three-phase dynamos which are to be installed in the near future furnish 900 KW at 2750 volts and make 107 r. p. m. To excite them, use is made of the two exciting dynamos which were formerly direct-coupled to the 400-HP dynamos. They are run at present by two induction motors. A transformer changes the high-tension current into the current required for the motors.

The continuous-current machines have cylindrically-shaped fields with poles pointing radially inward. The exciting dynamos are shunt-wound machines of 65 volts; the 200-HP street-railway dynamos are 500-volt compound-wound machines. The 400-HP railway dynamos, however, on account of the storage batteries with which they are used, and which are to be described later, are shunt-wound. The high-tension conductors, which lead from the machine to the switch-board, consist of cables armored with iron tape and, like the exciting and signaling conductors, are put underground.

The Storage Battery.—After the completion of the system in May, 1898, the power required for the street railway, not counting the loss in conductors, will fully amount in normal working to an average 370 KW; during morning and evening hours 500 KW and during very heavy traffic, when the whole reserve may be drawn upon, 600 KW. The fluctuations are estimated at about ± 100 KW.

In order to be able to cover these requirements, the losses in conduction and the fluctuations in load, and with a view to having a corresponding reserve on hand, the two 270-KW dynamos already described were installed, in addition to the two 140-KW dynamos; besides, provision has been made for a storage battery.

The battery comprises 276 cells. The greatest charging rate admissible is 226 amperes. The battery gives 370 ampere-hours at 370 amperes discharge rate, or 515 ampere-hours at 172 amperes discharge rate. The battery room is two stories high and covers a surface of 40 ft. × 20 ft. It is intended that the battery shall be charged at the time when least current is used, and furnish current when the consumption is greatest. Experience with plants of this size has shown

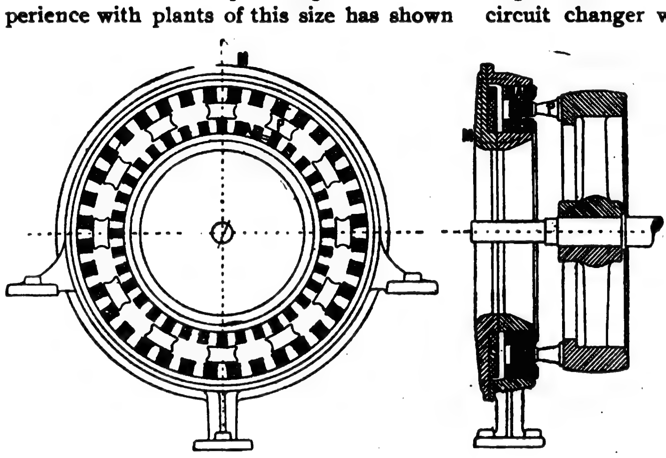


FIG. 10.—ELEVATION AND SECTION OF GENERATOR.

that the use of the battery as a so-called "buffer-battery" for the reception of the fluctuations, is not of primary importance, as these cause only oscillations which lie well within the limits of regulation of properly constructed dynamos. The main task of the battery is rather that of contributing to the current supply in the morning and evening hours of the greatest street-railway traffic; its "buffer action" plays only a subsidiary part, but, nevertheless, offers an additional advantage which is not to be underestimated.

For the street-railway system two different groups of feeding points and of bus-bars have been arranged, viz.:

1. The nearest feeding points, in the conductors of which the smaller loss of tension of about 60 volts occurs, obtain their current direct from the dynamos. 2. The more remote feeding points, with a greater loss of tension up to about 140 volts, for which the tension is raised from 550 volts to 640 volts. This is done by a booster in both conductors which produce 27 KW each, with a rise of 90 volts. These boosters, which have not been mentioned so far, are shunt-wound machines driven by a common direct-connected continuous-current motor. The bus-bars of the higher tension serve also for the purpose of charging the battery; to discharge, it is switched on to the bus-bars of lower tension. With a view to stopping the machinery during the night, and in order to be able to do with but one attendant during that time, it is proposed to let the battery eventually work a rotary transformer, transforming to three-phase current. When its capacity is fully made use of, the battery will give about 230 to 320 HP-hours to the shaft of the continuous-current machine. Assuming a six-hour period, this would still be sufficient, even though there be an increase of the nightly consumption.

The Switch-Board.—The switch-board (Fig. 9) is located on a gallery, at one end of the generating room. The panels on which the current is generated are on one side, and on the other are shown the circuits with all the outfit belonging to them, such as safety devices, switching, measuring, controlling and regulating instruments. The apparatus is divided into five groups: The generator switch-board, distributing switch-board, motor switch-board, testing-board and railway switch-board. On the generator switch-board are the phase indicator, fusible cut-outs, amperemeter, voltmeter, 3-pole switches, circuit changer with common phase indicator, station voltmeter, low-tension reduction voltmeter and rheostat, for each exciting machine. A branch further leads from the switch-board to a liquid load resistance which is placed in the gallery and is used when switching the three-phase dynamos in parallel.

On the distributing switch-board there is, besides the usual apparatus, a connection for an inductive resistance for equalizing, if necessary, the inductances in the legs of the three-phase circuit.

On the motor switch-board are the connections and starting rheostats for the above mentioned dynamotors used for excitation, which are such that each of the two 200-HP three-phase dynamos can be excited at will by any of the three dynamotors. The testing switch-board carries three voltmeters for testing in the secondary system of distribution and two compensating resistances for the voltmeter on the generator board, besides an automatic fault-finding apparatus which will be referred to further on. All fixtures are so arranged as to be readily observable, so that the probability of derangements resulting from improper attention are reduced to a minimum.

The switching in parallel of the three-phase dynamos is accomplished with the assistance of a voltmeter and phase indicator. When the machines are once switched in parallel, the phase indicator forms an important aid in judging the equality of the load on the steam engines. By this means it is rendered impossible for one of the three-phase machines to lose step through the synchronizing current exceeding the admissible limit. There is also attached to each machine an optical and acoustic signaling arrangement which is worked from the switch-board by the attendant. If one of the machines should prove to be too highly loaded, the attendant at the switch-board increases the magnetic field of the generator by diminishing the regulating resistances. At the same time he notifies the engineer by the signaling arrangement referred to, so that he may, by adjusting the governor spring, admit more steam. The reverse operation takes place whenever any

of the machines have too small a load. In this way working differences are quickly and safely corrected. For the purpose of regulating the total tension, the arms of all exciting rheostats are coupled together and a single hand-wheel moves them simultaneously. For experimental purposes there is on the switch-board platform a liquid resistance capable of being regulated and switched into the circuit of each separate three-phase dynamo by means of a simple switch.

The Distributing System.—On its first installation, the system of distribution was designed for a load of 29,000 50-watt lamps burning simultaneously, or equivalents in part in arc lamps, motors etc. The plant, when completed, is calculated for 45,000 lamps. The current is taken at 2750 volts to the high-tension system by means of five necting them as directly as possible with the transformer terminals.

The conductors of the high-tension circuits consist of triple concentric, lead-covered cables; those of the low-tension circuits are made up of triple concentric lead-covered cables armored with iron tape. Single cables have not been employed, because they become heated and are destroyed by the current induced in the metallic coverings.

The cross sections of the copper are so calculated that the losses of energy in the feeders on full load of the plant, shall not exceed as a maximum 4 per cent.; in the high-tension distributing system 1 per cent., and in the low-tension system 1½ per cent. In order to prevent false connections of the cable sections by confusion of the phases, the serial order of the phase wires in each cable section is properly marked. There Allgemeine Electricitäts Gesellschaft. It indicates continuously the condition of the insulation of the system and of the voltages existing there, and thus contributes materially to the maintenance of safe working. The arrangement depends upon the action of relays, switched into the test-wire conductors and which, when a fault occurs, cause the falling of a drop marked with the district; at the same time an alarm is sounded. As a result faults can be readily removed, for the apparatus indicates their location and renders their exact finding easy. It is to be mentioned that in addition to the signaling of faults by the use of test wires, the voltage in the secondary system can at the same time be ascertained; the test wires of the latter are traversed normally by current and their relay is so constructed as to remain in equilibrium at normal pressure. Not until

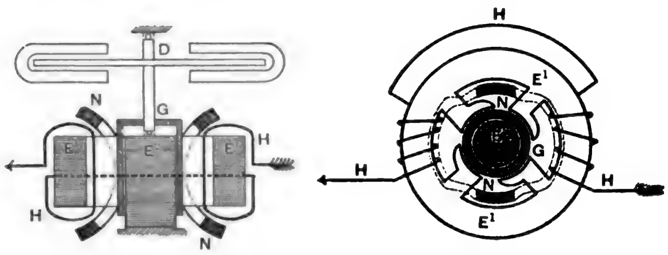


FIG. 11.—DIAGRAM OF ALTERNATING-CURRENT METER.

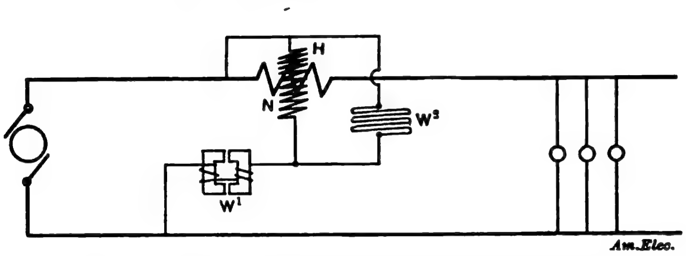


FIG. 12.—ALTERNATING-CURRENT METER CIRCUITS.

feeders, of which four lead to the main feeding points provided for at the first installation, while the fifth is destined for the supply of the harbor district alone; it supplies this with current for a motor load of about 100 HP for cranes, hoists, etc. From these main feeding points the high-tension distributing system branches off over the whole lighting district and feeds the transformers. These change the current from 2750 down to 120 volts, which corresponds to a circuit voltage of 118 volts, allowing for the drop in the secondary-circuit conductors.

The places for the installation of the transformer were, as far as local conditions permitted, so chosen as to render possible a direct connection of the circuits of larger consumers with the transformers. A not inconsiderable economy of copper was thereby attained and fluctuations avoided which would have otherwise influenced the neighboring lamps on switching in and out on secondary mains.

The transformers consist of three superimposed coils which are closed magnetically on both sides. The efficiency varies from 92 per cent. at half, to 95 per cent. at full load. So far, 64 transformers of a total of 739 KW capacity have been installed, of which 47 are put in revolving columns of sheet-iron with doors, which are also used for affixing bulletins. Six transformers are put up in buildings, eleven in ten underground stations, which are walled chambers, with an opening for entrance and arrangements for ventilation.

There is room for two transformers in each transformer station. The stations contain bus-bars with connections for lighting and measuring instruments, besides a schematic representation of all circuits proceeding from them.

The use of fittings and couplings in the high-tension circuits was avoided by con- are laid provisionally about 14.5 miles of feeders of three times 10 (No. 7 B. & S.) to three times 95 (No. 000 B. & S.) sq. mm. cross-section of copper; about 15 miles of conductors of the high-tension distributing system of three times 10 to three times 25 (No. 3, B. & S.) sq. mm. and about 20 miles low-tension conductors of three times 16 (No. 5, B. & S.) to three times 95 sq. mm.

For the purpose of control, test wires are introduced into both the high- and low-tension cables, and the distributing system is divided into eight districts. The test wires lead first to the main feeding points and thence by special test-wire cables to the cen-

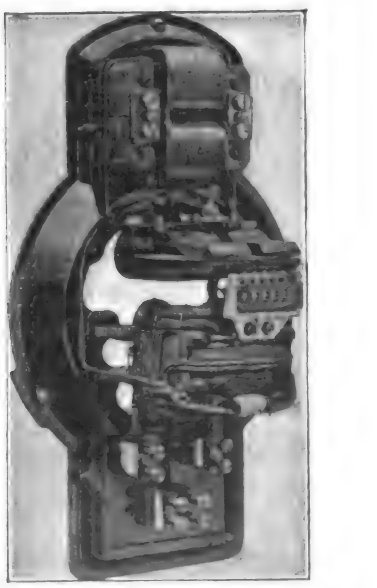


FIG. 13.—ALTERNATING-CURRENT METER.

tral station. The fault-indicating system already spoken of, was first introduced in the Berlin electric plants, where it proved so successful that it has since been used in every large electric plant installed by the a change of voltage occurs does the alarm mechanism begin to operate.

While, as has already been said, the circuits of the larger consumers are fed directly by the transformers through special conductors, the circuits of the smaller consumers are connected singly or in twos with the secondary system. House installations with a total consumption of over 1500 watts are connected with three conductors, and those of less than 1500 watts are connected only with two conductors. The latter are, accordingly, provided with simple alternating-current meters.

This meter is constructed on the rotary-field principle, with artificial phase adjustment for a single-phase alternating current. It depends essentially upon the revolution of a simple copper bell, *G*, which, as the armature of a fixed core, *E*, rotates in a magnetic field with prolonged pole-shoes, as shown in Figs. 11 and 13. The main winding, *H*, is of the Gramme ring type. The shunt winding, *N*, is in frames within the grooves, and the current therein can be varied by an inductive resistance, so as to make the meter read in KW-hours, thus avoiding the use of a constant. The action of the meter-motor is controlled by a damping-disk, *D*, which rotates in a constant magnetic field. With no load, the motor is checked by a small iron wire fixed to the damping-disk, which wire is attracted by permanent magnets. This small wire is of such shape as to securely stop the rotating part when there is no current, and violent shaking will not release it from the magnetic attraction which holds it; the least current, however, overpowers the magnetic attraction. Phase difference is produced in the motor of the meter by adding to the difference of phase given by the special choking coil, another produced by the parallel connection with the shunt winding of a non-

inductive resistance, W^2 (Fig. 12). This figure shows the connections of the motor in their relation to an alternating-current supply.

The counter is so sensitive that it operates without fail on the smallest load, and is not affected by external magnetism. It can be used for circuits free from inductance, as well as for inductive circuits (motors, arc lamps, transformers, etc.), and admits, temporarily, of an overload up to 100 per cent. Experiments made at the Electrotechnic Experimental Station at Munich, in July, 1896, showed that the revolutions of the counters increase in direct proportion to the consumption of watts, the record being a straight line.

This meter can, of course, be also used for three-phase currents and it is therefore employed on the distributing system of Strassburg. For connection of motors with a distributing system in which there is a neutral point or where a conductor can be run without difficulty from a dynamo or a transformer to a meter, only one meter is necessary. It is cut into one of the three conductors and a wire is run from it to the neutral point. In this case the watt-hour indications are to be multiplied by 3.

For plants with unequal load on the branches two meters are required, whose readings are added. Special induction motor-meters built according to the systems described, will, however, be used, and they are now in course of construction.

It is to be noted, finally, that the city of Strassburg has reserved for itself the right to acquire by purchase, after the lapse of fifteen years, the plant under certain definite conditions.

The charge per KW-hour is 14.5 cents for lighting purposes. When the annual consumption exceeds 3000 KW-hours, the charge is only 9.5 cents. For power transmission, heating and electrochemical purposes, the cost varies from five cents per KW-hour for a yearly consumption of 1000, down to 2½ cents for an annual consumption of 10,000 KW-hours and over. A further reduction of 10 per cent. on these prices to the commonalty and city is provided for.

The plant was started up on May 15, 1895, the time fixed by contract. It was coincident with the opening of the Industrial Exposition of Strassburg in the Orange Park, where a part of the arc lamp illumination, as well as the operation of several 10-HP motors, was done by the electric plant. For the carrying of passengers on the Ill, storage battery boats were used, the charging of which was done by continuous-current machines driven by two induction motors of 30-HP each.

The Street Railway.—Special cables were laid to Kleber Place, which is situated in the center of the city about a mile from the central station, in order to supply to the street railway 500-volt continuous current, amounting at first to 300 amperes, but later to a maximum of 1200 to 1400 amperes. The conductors are two lead-covered cables armored with iron tape, the copper having a cross section of 185 mm. (365,000 circ. mils.). In the waiting pavilion on Kleber Place a watt-hour meter has been put up for the measurement of the energy used. Behind it the current branches off from a cable box in four directions and is led by means of vertical cable connections to the trolley conductors, which are furnished with lightning arresters. The return is through the rails to Kleber Place and thence through the cable to the central station.

The rolling stock is being enlarged to 117 cars, each having twenty seats and fourteen places for standing, and being fitted with two motors of 25 HP each. The completed system will for the present have a length of track of 27 miles.

THE SPRAGUE MULTIPLE-UNIT ELECTRIC RAILWAY SYSTEM.

On Monday July 26, the first public exhibition was given of Mr. Frank J. Sprague's new multiple-unit electric railway system, a trial train of six 42 ft. elevated railway cars being then run over the tracks of the General Electric Company at Schenectady, N.Y.

The cars used are to form part of the equipment of the Chicago South Side Elevated Railway, the contract for the motor equipment of which had been awarded to Mr. Sprague. The main idea of the Sprague system is that it provides means for the individualizing of cars, and yet admits of their being concentrated in trains without detriment to either method of operation. Each car is complete as it runs, yet if a half dozen of them are thrown together, they lock step at once and the train operates as a unit.

Each car at Schenectady was equipped with two G. E. 57 motors rated at 50 HP each. The Sprague controlling system is similar in some respects to that employed with the Sprague electric elevators. The motor controller itself is of the usual type, and on the cars at Schenectady was placed under the side seats at one end of the car in five cars and on the inside of the platform canopy on the sixth. The controller is operated by means of a small pilot motor as in the Sprague electric elevator system. The mechanism controlled by the motorman is in a small case on each car platform, as shown in Fig. 1. The case is about 10 ins. in diameter by 4 ins. in height, inside of which are several contact blocks. By moving a projecting handle all the necessary movements of speed are obtained.

While the cars are in motion the operator retains hold of the controller lever which, if let go, immediately returns to the "off" position and breaks the motor circuit. The motorman may control the train from either of the platforms of any one of the cars, the controllers on each car having simultaneous motion corresponding to each movement of the handle operated by the motorman.

Underneath each car runs a flexible cable equipped with a peculiar interlocking coupling so that, no matter what is the headway, any car can be almost instantly thrown in or detached, in the former case at once answering to the control of the train motorman. At Schenectady additional cars were coupled to a train running at 25 miles per hour.

FIG. 1.—END OF CAR, SHOWING CONTROLLER.

The details of the system have not yet been made public and therefore it can merely be said that they include automatic devices similar to those on the Sprague electric elevators, whereby every contingency that may arise in operation is provided for, such as burnt-out motors, defects in motor controllers, breaking of any of the circuits, etc.

The operation of a car is substantially as follows: The motorman standing on the front platform has his hand upon the lever, the movement of which controls a pilot motor in each car attached to an ordinary railway motor controller. As the handle is moved, simultaneous motion is given to all the pilots of the train, which in turn move the motor controllers to the desired notch. Each car is in itself a unit, and the train may be added to or substracted from in the time it takes for mechanical coupling, the motorman not necessarily needing to have knowledge of such additions or subtractions.

The whole train of cars at Schenectady was run at 33 miles an hour and then split up into various groups of its component parts, making again the same rate of speed. The passengers on board gave an approximation to the normal conditions of an ordinary train load. On leaving a station the train was quickly accelerated and on stopping there was quick retardation, with a minimum of power used between, and this was as marked with six cars as with one.

FIG. 2.—TRAIN AT SCHENECTADY EQUIPPED WITH SPRAGUE SYSTEM.

Each car had air brakes and an automatic air compressor, circuit breaker and electric lights, all drawing their supply from the main line circuit, which in this instance was carried by an outer third rail, as shown in Fig. 1.

On one of the cars was a movable vestibule of Mr. Sprague's invention, which enables the motorman on any ordinary platform to be enclosed either wholly or in part, but gives him a full view of everything from one end of the train to the other. When he leaves the vestibule, the platform can be immediately thrown open for passengers to leave or enter by. It is intended that the motor controller, instead of being placed under the seats, shall be mounted above a swinging trap door in the canopy, thus placing it within immediate reach of the operator.

The important points of the Sprague system are the divisibility of traffic of which it admits, and a maximum tractive power, which enables a maximum accelerating effort to be obtained. About 58 per cent. of the weight of the train and its load is available for traction, which is vastly in excess of what can possibly be obtained by any locomotive or single-car system. Moreover, this weight is distributed in an ideal manner over the rails.

The relation of these features to increased headway and quicker service, even with complete trains, is evident. On the other hand, in running a single car in light hours, time is saved to passengers. Of the two time elements in an elevated railway journey, one is the waiting time at the station and the other the time occupied by the trip. The former element of time consumption is very largely reduced by the Sprague system, and in point of time-efficiency places an elevated system on a par with cable or trolley cars running under only a few seconds headway on the street level. At the same time, while the surface cars cannot be safely massed into big trains, the clear track of the elevated permits the cars to be all grouped as needed and the trains run at the same speed as if they were only individual cars.

At a trial of the Sprague system at Schenectady on Aug. 13, officials of the Brooklyn Elevated Railway were present and were reported in the daily press as expressing themselves highly in its favor. It is rumored that upon the reorganization of the Brooklyn elevated roads, which, it is reported, will soon be consummated, the Sprague system of multiple-unit electric traction will be adopted.

THE MASSENA WATER POWER ELECTRICAL GENERATING PLANT.

In our issue for August announcement was made for the commencement of work on the canal of the St. Lawrence Power Company at Massena, N. Y., and we are now enabled to give an account of some of the more important features of this great undertaking, which involves the immediate utilization of 75,000 HP with a prospective utilization of 150,000 HP.

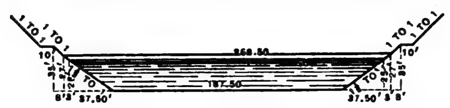


FIG. 1.—SECTION OF CANAL.

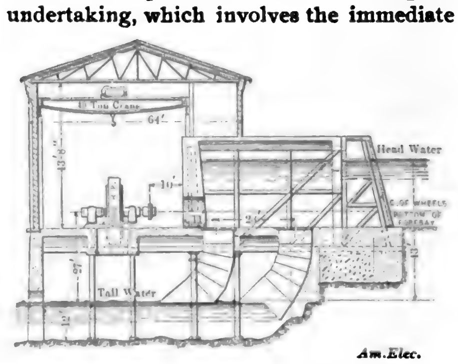


FIG. 2.—SECTION OF POWER HOUSE.

Fig. 5 is a map showing the location of the plant and canal, and Fig. 2 is a section of the latter. The St. Lawrence River has a fall of more than 50 ft. over the Long Sault rapids between the mouth of the canal and the point where a small stream—the Grass River—flows into the St. Lawrence. The canal will connect the St. Lawrence with the Grass River at a point of the latter where the water will have a fall to its bed of 47 ft., of which there will be available at the turbines an effective head of over 40 ft.

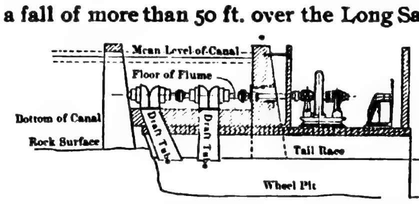


FIG. 3.—ARRANGEMENT OF DYNAMOS AND TURBINES.

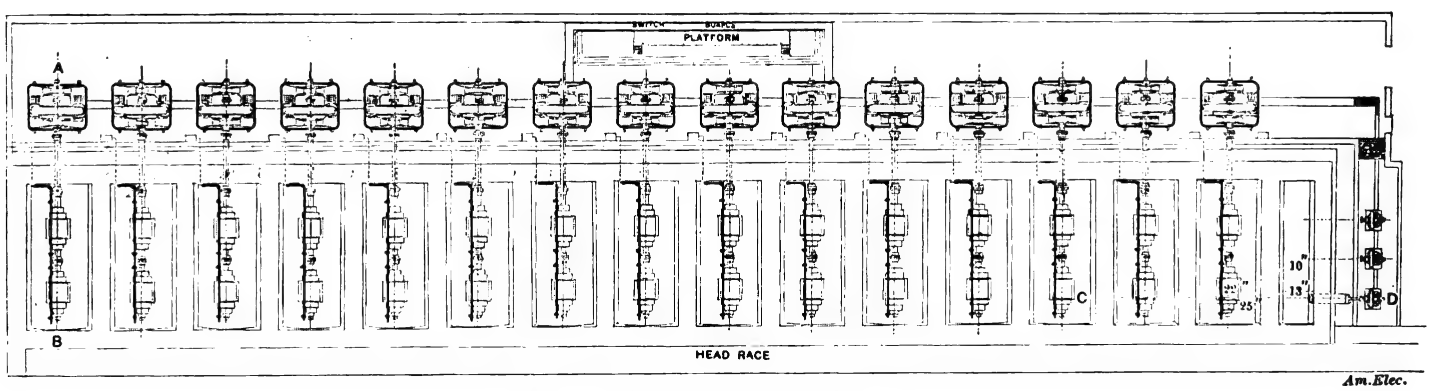


FIG. 4.—PLAN OF POWER HOUSE.

The power house will be built on the bed of Grass River below the canal outlet, and will be 600 ft. long × 130 ft. wide. Fig. 4 shows a plan of the power house, and Fig. 2 a transverse section. The turbines will be

of the horizontal-shaft type, two to each shaft and each pair developing 5300 HP. Fig. 3 shows the setting of the pairs and the draft tubes.

The turbine shafts, which are 80 ft. long, will extend through a wall separating the canal or turbine chamber and the power house. Each shaft will have mounted on it a great ring of steel which will carry on its circumference twenty external pole-pieces, the ring and pole-pieces being of one solid casting of steel. The former will have an extreme diameter of 15 ft. and be about 3 ft. wide and supported by a massive hub having ten radial arms or spokes. Each of the machines will weigh 350,000 lbs., stand 22 ft. high above the top of the foundation and occupy a floor space of 22 ft. × 18 ft.

The stationary part of the dynamo will form the armature and will consist of a large ring or cylinder, the inner surface of which will be made up of plates of soft thin steel on edge held by the massive outer ring of cast iron; the inner surface of the steel plates will have slots in which will be laid copper bars parallel with the shaft of machine, insulated from each other with mica and in which will be generated the three-phased currents.

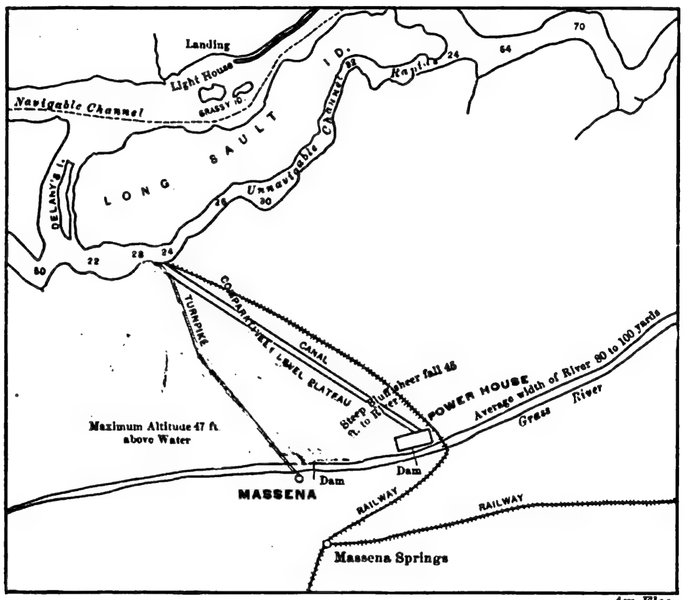


FIG. 5.—MAP SHOWING LOCATION OF CANAL AND PLANT.

The poles of the revolving portion or field of the machine will be wound with copper ribbon. The speed will be 180 r. p. m. and the current will be generated at a frequency of 30 periods per second.

The owners of the St. Lawrence Power Company are Messrs. Stewart & Company, 40 Wall Street, New York; the engineer is Mr. John Bogart, formerly New York State Engineer.

Contracts for construction of the plant have been let as follows: For excavating the canal, building the power house and hydraulic work, to the Lehigh Construction Company, Limited, of South Bethlehem, Pa.; the fifteen 5000 HP generators will be furnished by the Westinghouse Electric & Manufacturing Company, and the turbines by the Stilwell-Bierce & Smith-Vaile Company, of Dayton, O. 75,000 HP electrical energy are to be available before the end of next year.

SELECTION OF ALTERNATING-CURRENT APPARATUS FOR POWER TRANSMISSION.

MACHINE INSULATION.

BY H. E. RAYMOND.

In a preceding article on this subject there were given a few conditions relating to the selection of certain types of polyphase machinery, and a few general statements concerning operation.

One very important subject was not touched upon, however, and it is the purpose of the present article to bring to notice the vital point—high insulation. This item in machine design holds its value regardless of the arrangement of plans and methods of operation, but we will refer to it as in a specific case.

Suppose we have decided to adopt a system using tri-phase, direct-coupled power generators with stationary field, designed to allow of an ample increase in field excitation before the saturation point is reached, and wish next to decide between high-voltage machines, directly connected to the lines, or low-voltage with step-up transformers. Of course, we wish our system to be as efficient as the conditions of operation and attendant circumstances will allow, but, if continuous operation is of paramount importance, we are ready to sacrifice to it a few per cent. of efficiency.

In tri-phase generating apparatus there are two main types, the main characteristics being, in the one, simplicity of winding, giving the saw-tooth wave of E. M. F., and insulation deemed sufficient for ordinary voltages up to 3000 or 4000 volts; and in the other a multi-tooth winding, giving nearly a sine curve of E. M. F. The voltage employed in the latter must be necessarily lower than in the first, as the multiplicity of windings results in a number of crosses. The first type has considerable armature reaction, and on short circuit gives about double full-load current. The regulation is not as close as in the latter, full non-inductive load drop being from 10 per cent. to 15 per cent. without compounding. The multi-tooth machines have much lower armature reaction and on short circuit give about four times the full-load current. The regulation is excellent, however, the variation due to load, at constant field excitation, being about 4 per cent. to 5 per cent. Opinions as to which of these types is most satisfactory must be founded upon the conditions involved, and in general will be influenced by personal preference. Most of the manufacturing companies advise, for distances up to from 6 to 10 miles, machines of voltage up to 4000 volts and for longer distances the lower-pressure machines with transformers, stepping up to 10,000 and over. If every line and transmission system were as they should be, or as we should like them to be, this would be the best and simplest way.

Machines as now manufactured, are apt to cause a great deal of trouble if operated at 3000 to 4000 volts, on lines acting as lines do. Resonance due to the fundamental frequency is seldom likely to be present, and that due to the lower harmonics is almost as scarce. The extremes of this phenomenon need not be feared in practice, as they may be overcome by altering the machine-frequency, amongst other methods. That due to the higher harmonics is often present, and, though not to a very dangerous extent, it is sufficient to cause serious trouble. The coils in the slots may be insulated well enough, for which we find mica best, but the turns across the heads of the armature, the leads to the collector rings, the rings themselves, the brush holders, and brush-holder yokes, can stand a great deal more mica, hard rubber and air space. The rise in pressure due to this resonance from the upper harmonics may be 50 per cent. to 100 per cent. of the impressed machine voltage, and sparks are always ready to jump where-ever and whenever the opportunity occurs. In practice we cannot keep a man standing always at the brushes of each machine, and often a very few minutes' absence may give time for a brush to start cutting the ring. This causes a small amount of copper dust to be deposited somewhere on a "live" portion of the machine, and gives a spot for a spark to jump from. Or the presence, in the air, of this dust, will sometimes furnish sufficient path for this high tension to discharge across.

The protecting shields on the ends of the armature are also a source of trouble from this cause. It is deemed necessary to protect and to ventilate the coils in this way and the means of ventilation often result in serious injury. For example, several instances have come to our notice in which a discharge took place from a coil to the inside of the shield, an arc following. This was, of course, noticeable at once, but before the machines could be shut down, the intense heat from the arc was carried around the hollow of the shield, burning off the insulation on the end of every coil. In order to provide against this, we placed blocks around the shield at intervals so as to make fire-proof sections, lined the inside of the shield with mica and asbestos, covering up the ventilating holes, and packed closely about every coil, shredded asbestos saturated with P. & B. paint. The machine practically runs as cool as it did before, and if any coil is damaged now, the injury is apt to be confined to one spot.

It is obvious that this method of protection is but a make-shift, and ample allowance made in the design would be far better. If all metal can be kept at least 1½ ins. from the coils, except in the slots, and plenty of mica used there, the danger, from this one trouble, at least, will be greatly minimized. The use of hard-rubber rings between the collectors can also be increased to advantage; 2½ ins or even 3 ins. greater

radius than that of the collector ring is none too much. The hard-rubber washers and bushings on the brush-holder studs are none too large, and until we increased the size of ours over 50 per cent. we experienced a great deal of trouble with them. The current would jump around the washers from the collar of the stud, through the center holes, and, in fact, at every available point. The studs and yokes should certainly be well insulated, and covered at exposed parts with hard rubber or moulded mica in some form. It is certainly far better to go to an extreme in insulation than it is to undergo the expense and soul-harrowing results of a short circuit across the brushes, or a couple of grounds to the frame of the machine. These discharges to the frame or across the brushes are generally accompanied by such displays of light and sound as would justify the belief that a battery of artillery had just been set off near by, and a few occasions of this nature will unnerve the average dynamo tender to such an extent that he will, unwillingly perhaps, half neglect his machines from fear of them.

If the manufacturing company will amply insulate the high-voltage parts of the machines, and guarantee the line and system to be free from resonance, except in the slightest degree, this high-voltage, saw-tooth type of machine will be satisfactory, doing away, as it does, with the transformers and their attendant losses.

If, however, there is water power in sufficiency, it is the writer's opinion that the low-voltage generators and step-up transformers will prove more satisfactory. The regulation is much closer, the danger to the attendant is less and his consequent fear is diminished. They can more easily be kept clean, and safety to themselves so assured. The arcs formed when the circuit is opened are less vicious, and in an emergency, ordinary switches can be opened with the knowledge that success is likely to follow the attempt. Circuit breakers can be installed with greater security. The line loss can be lessened and the first cost of the same be also decreased. Transformers can be insulated, and are now, so as to stand safely very high voltages, and have the advantage of being without movable contacts with a tremendous difference of potential between them.

The loss in transmission will be greater if the distance is moderate than it would be with generators directly connected to the line at any allowable pressure, and if the amount of water power is limited to the actual demand, the system could not be used. But if the water power is in surplus, save all the power you can by direct-coupling mechanically everything you can, and comfort yourself with the knowledge that your transformer loss is compensated for in the increased element of safety, in probable continuous and successful running, and in the better regulation and increased power capacity the lower-voltage, sine-wave machines exhibit.

We may have occasion to change this opinion in a short or a long time as the case may be, but in the present stage of alternating-current machinery, it has appeared from our experience, that none of the higher-voltage types possessing any close degree of regulation are insulated sufficiently to successfully cope with the externally-induced dielectric strains. Perhaps such a machine as the General Electric Company's A. P. type could be wound so as to allow ample space between the crosses of the coils by increasing the distance of the outside coil from the core, and heavily insulating these ends. By substituting coils of a number of turns for the solid bars now used, the voltage could be increased, the regulation and wave form partially preserved. The close regulation without compounding would be a great boon and the smaller number of turns in each coil would allow them to be well insulated. Such a machine would be necessarily large, but close regulation is a more vital point in power transmission than perhaps most of us have appreciated. One more point. Don't skimp on the size and capacity of the generators. Lots of opportunities for small increases in the load from time to time will occur, and the first thing we know we are constantly carrying overloads and have no reserve.

In regard to the methods of exciting we will speak of two—individual machine exciters and a common exciter. If we are not to run in parallel at all, we may well use individual exciters, and in this case the greater responding capacity of compound over shunt generators, unless the shunt type is run with a great deal of resistance in the field, will prove of advantage in the generating station. For synchronous motors a shunt machine is excellent, for its rise in voltage as the speed increases, serves as a good indication of the approach of synchronism, and the drop in the exciter voltage when the load is placed upon it, enables the motor to be brought into step with the generators, with gradual diminution of the line currents. If our generators are to be run in parallel, a common exciter will prove most convenient, for if a heavy pull comes on, a general increase of machine pressure can be obtained at once by simply increasing the exciter voltage, separate regulation being obtained by means of the main field boxes.

TEST OF AN ELECTRIC HEATER IN COMPARISON WITH COMMERCIAL ALCOHOL (95 PER CENT) AND WOOD ALCOHOL.

BY PROF. JAMES S. STEVENS AND BURTON S. LANPHEAR.

A series of experiments recently carried on in the physical laboratory of the University of Maine, yielded some interesting results bearing on the relative cost and efficiency of certain methods of heating. The object of the experiments was to apply heat furnished by the electric heater, a lamp burning 95 per cent. alcohol and a lamp burning wood alcohol, to equal masses of water under conditions as nearly similar as possible. The calorimeter used was made of copper plated with nickel and had a capacity of one-half a litre. Account was taken of the water equivalent of the calorimeter and stirrer, the loss by radiation and vaporization. These factors were found to be small and for our present purpose negligible, since they were likely to operate equally in each test. The electric heater was a 4½ in. plate heater made by the American Electric Heating Corporation.

It should be said that the shape of the calorimeter was such as to be better adapted to receiving heat from the lamps than from the electric heater, since its diameter was only 2¾ ins. and that of the heater plate was 4½ ins. A calorimeter constructed after the model of the pan of a chafing-dish would, we think, have given results still more favorable to the heater.

The experiments themselves were very simple in their character and need no further explanation than that afforded by the tables and curves.

The most practical part of the test is, of course, the determination of the relative cost of the three methods of heating.

It is assumed that alcohol costs $3 per gallon, wood alcohol, $1.80 per gallon and that electric energy can be supplied for fifteen cents per kilowatt-hour. Any changes in these prices may easily be taken into consideration in the final result. Using the above figures as a basis, the following results were obtained.

Ninety-five per cent. alcohol consumed during the run	14.9	gal.
Wood alcohol consumed during the run.	23.5	"
Volts supplied to the electric heater	51.00	
Amperes supplied to the electric heater.	4.23	
Calories produced by 95 per cent. alcohol	19,185	
Calories produced by wood alcohol	20,153	
Calories produced by electric heater	18,750	
Cost of run with 95 per cent. alcohol	1.4	cts.
Cost of run with wood alcohol	1.3	"
Cost of run with electric heater	0.96	"
Cost per million calories 95 per cent. alcohol	75.1	"
Cost per million calories wood alcohol	64.0	"
Cost per million calories electric heater.	51.2	"

TABLE SHOWING RISE IN TEMPERATURE FOR PERIODS OF 1 MINUTE EACH FOR THE THREE SOURCES OF HEAT TESTED.

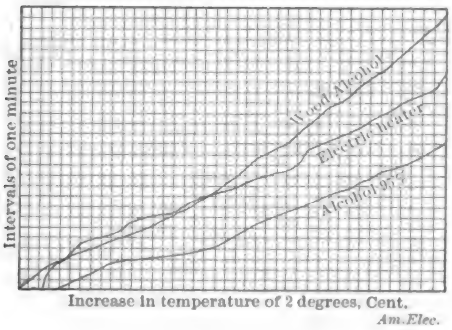
ALCOHOL, 95%		WOOD ALCOHOL.		ELECTRIC HEATER.	
Time interval.	Temperature.	Time interval.	Temperature.	Time interval.	Temperature.
0 min.	25.°0 C	0 min.	17.°2 C	0 min.	22.°0 C
1 "	29.9 "	1 "	20.6 "	1 "	22.8 "
2 "	33.9 "	2 "	24.4 "	2 "	24.8 "
3 "	39.5 "	3 "	28.9 "	3 "	27.4 "
4 "	47.8 "	4 "	33.9 "	4 "	29.0 "
5 "	56.2 "	5 "	39.5 "	5 "	35.5 "
6 "	58.9 "	6 "	43.3 "	6 "	38.5 "
7 "	62.8 "	7 "	47.2 "	7 "	45.4 "
8 "	67.3 "	8 "	51.2 "	8 "	50.5 "
9 "	72.8 "	9 "	55.0 "	9 "	55.6 "
10 "	77.8 "	10 "	57.3 "	10 "	60.2 "
11 "	82.3 "	11 "	60.6 "	11 "	67.0 "
12 "	85.6 "	12 "	63.6 "	12 "	71.2 "
13 "	91.2 "	13 "	66.1 "	13 "	72.0 "
14 "	95.6 "	14 "	69.4 "	14 "	76.0 "
15 "	100.0 "	15 "	71.7 "	15 "	81.0 "
		16 "	74.5 "	16 "	84.5 "
		17 "	76.7 "	17 "	88.0 "
		18 "	80.0 "	18 "	91.0 "
		19 "	81.7 "	19.8 "	97.0 "
		20 "	84.5 "	20 "	98.0 "
		21 "	87.2 "	21.4 "	100.0 "
		22 "	89.5 "		
		23 "	91.7 "		
		24 "	93.2 "		
		25 "	95.6 "		
		26 "	96.7 "		
		27 "	98.3 "		
		28.75 "	100.0 "		

TABLE SHOWING THE RELATION BETWEEN THE TIME INTERVAL AND THE RISE IN TEMPERATURE.

	Range of Temperature.	Time Required.	Mass of Water.
Alcohol, 95%	75.°0 C	15.0 min.	255.8 g
Wood Alcohol.	75. 0 C	28.75 min.	268.7 g
Electric Heater.	75. 0 C	21.4 min.	250.0 g

It may be said that these experiments seem to indicate that if electric energy can

be furnished for fifteen cents per kilowatt-hour (which is believed to be slightly in advance of the average rate) the use of the electric heater is about 30 per cent. cheaper



CURVE OF TESTS.

than the commercial (95 per cent.) alcohol, and about 18 per cent. cheaper than wood alcohol for doing the kind of work for which the heater was designed.

GENERAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The meeting of the American Institute of Electrical Engineers held at Eliot, Me., July 26, 27 and 28, was a successful one if judged—as it should be—by the number and character of the papers and the value of the discussions brought forth. The attendance was not large—indeed was quite small—but included perhaps a majority of those members of the Institute upon whom the value of its *Transactions* depends.

The members present thoroughly enjoyed the occasion, not only on account of the beauty of the locality and the hospitable reception accorded by Miss Farmer and her associates in the Greenacre Conference, but also on account of the opportunity afforded to gain an insight into the purposes and methods of the Conference, whose sessions were held as usual.

As the meeting was held at Eliot, Me., the home of the late Prof. Moses G. Farmer, to commemorate the fiftieth anniversary of his exhibition of the first operative electric railway (July 26, 1847, at Dover, N. H.), the life-work of this great inventor and noble character received a fitting recognition. In the hall in which the sessions of the Institute were held was an exhibition of apparatus constructed by him which forcibly illustrated his great constructive and inventive ability, and directed renewed attention to the fact that Farmer, as has often been remarked, lost many and bright laurels by being almost always a quarter of a century or more in advance of the age—his work inuring to the benefit of others when later the time became ripe for exploitation. Commemorative addresses in honor of the occasion were delivered by Profs. Dolbear, Brackett and Barker, under the auspices of the Greenacre Conference, and by Dr. Kennelly, Prof. Perrine and Prof. Elihu Thomson on the part of the Institute.

The members in attendance at the meeting will always treasure the remembrance of the cordial hospitality of Miss Sarah J. Farmer, the presiding genius of the Greenacre Conference, of Mrs. Kate Tannatt Woods and the others who rendered their brief sojourn at Eliot so agreeable; and it is not too much to say that all, during their brief stay at Eliot, became imbued with feelings of the highest admiration for the New England intellectual movement having its expression in the annual meetings at that place.

The presidential address of Prof. F. B. Crocker had for its subject "The Precision of Electrical Engineering," in which the popular idea of the indefinite and hazy nature of electrical science, was contrasted with its real nature as the most exact and definite of all the applied sciences, and the real founders of which, from the days of Ampère to the present, have been the reverse of the "wizards" and others with whom electricity is associated in the minds of the general public.

Many of the papers read gave the results of exhaustive research and study of subjects which, though not of general and immediate practical interest, were none the less valuable from elucidated obscure points affecting theory and design. Among these was the paper on the "Alternating-Current Induction Motor" by Charles Proteus Steinmetz, which forms a most valuable contribution to the mathematical theory of induction motors. A paper by Prof. W. E. Goldsborough on the "Effect of Armature Inductance upon the Electromotive-Force Curves of an Alternator," which gives the result of a series of experiments carried on in the electrical laboratory of Purdue University for the purpose of investigating the subject treated; the numerous curves given in this paper will be of much future use with respect to both the theory and practice of the design and operation of alternators. A paper by Prof. R. B. Owens on "Armature Reactions in Rotary Transformers" which contains many curves showing the instantaneous distribution of induction over the pole-pieces of a rotary converter for different armature positions and conditions of loading. All the above papers are so special or mathematical in their character as not to admit of abstract.

Two other papers read, of a nature not admitting of satisfactory abstract, were one by Mr. Horatio A. Foster, on "The Cost of Steam Power," and another by Mr. M. H. Gerry, Jr., on "Electric Traction: Notes on the Application of Electromotive Power to Railway Service, with Illustrations from the Practice of the Metropolitan Railway of Chicago."

The first-mentioned paper contains tabulated data of the cost of steam power from a large number of steam plants tested by the author, the data showing, as far as possible, the conditions of the plants tested without going into details not necessary for a clear understanding of the results obtained. The plants, twenty-two in number, cover ten different applications of steam power and were selected, not in order to show the very considerable variation in results that were given, but for availability and for variety of types and of applications. The data are very complete and their value enhanced by descriptive remarks of the various plants tested.

The author pointed out that any general statement of the cost of power per horse power per annum is incorrect, and that no such statement of an average power is of any value whatever, unless it be for plants employed in similar work and under exactly similar conditions; and even then the amount of power developed is a factor so largely affecting the unit cost that it is quite fair to say there is no average unit cost for steam power that is safe for general application.

The paper by Mr. Gerry is a discussion of some of the more important problems arising in connection with the application of electric power to the heavier classes of railway service, a number of tests and diagrams of the Metropolitan Railway of Chicago being introduced for illustration.

In view of the fact that the general meeting of the Institute was held at Eliot, Me., in commemoration of the fiftieth anniversary of Prof. Moses G. Farmer's entry into the electrical field, a paper by Adam Bosch, entitled, "An Historical Sketch of the Fire-Alarm Telegraph" was peculiarly appropriate, dealing, as it did, very largely with the successful pioneer work of Prof. Farmer in this branch of electrical application, of which he may be considered the father.

A paper by Messrs. Putnam A. Bates and William C. Barnes, on the "Effect of Heat on Insulating Materials" gave the results of experiments instituted with a view to discovering the cause of the discrepancy existing between previous experiments on the subject of the paper, the results showing that the discrepancies are assignable to a very simple cause, as noted elsewhere in this issue.

The other papers read at the Eliot meeting, abstracts of which will appear in these columns, were, "A New Form of Induction Coil," by Prof. Elihu Thomson; "Electric Metering from the Station Standpoint," by Caryl D. Haskins; "Efficiencies and Life of Carbons in Enclosed Arc Lamps," by W. H. Freedman; and "The Economy and Utility of Electrical Apparatus," by Prof. J. P. Jackson.

THE ECONOMY AND UTILITY OF ELECTRICAL COOKING APPARATUS.

In a paper with the above title, read at the Eliot meeting of the American Institute of Electrical Engineers, Prof. J. P. Jackson gave the result of some tests with electrical cooking apparatus in practical family use, extending over a period of six weeks.

The apparatus consisted of an oven, broiler, three flat stoves and flat-irons, all for a 110-volt circuit. The oven had three heats, corresponding to 3, 10 and 17 amperes respectively; the broiler was of 12 amperes capacity, the stoves of 2, 4 and 5 amperes and the flat-irons of 1, 5 and 6 amperes. In what follows, costs are based on a rate of 10 cents per ampere-hour of current.

The meals were for a family of six, and the following bill of fare and cost is given as an example:

Breakfast: Rolled oats, coffee and beefsteak. Dinner: Roast beef, potatoes, asparagus and toast, pie and coffee. The cost of cooking the breakfast was 13.55 cents, and of the dinner, 29.8 cents. The average cost of meals during the period covered was 13.1 cents.

Four pies could be cooked in the oven at

a cost of 2.05 cents per pie. Two large loaves of bread were baked at a cost of 6.1 cents per loaf. An ironing requiring four hours—cost 22.7 cents.

Among the conclusions of Prof. Jackson are the following:

For light housekeeping, such as is practiced in small city apartments, or in many larger houses during the summer months, no other method presents so many desirable features. For such housekeeping a disk stove, using 500 or 600 watts, and a broiler, using about 1200 watts, would be sufficient for a small family, and would cost from $20 to $30. A tea-kettle or immersion coil might be added at a cost of from $6 to $10. A special pair of wires would of necessity have to be run into the cooking room from the house or apartment supply mains.

Electric cooking apparatus could be used with facility in boarding houses and restaurants for purposes which require an even temperature, such as is needed in baking griddle cakes, boiling eggs, etc.

Where electricity is available, nothing could be more convenient than a small electric stove, requiring 300 or 400 watts, for the many uses to which at present the alcohol flame is put, such as the afternoon tea-kettle, chafing-dish, toaster, etc.

In the shop, the glue-pot, solder-pot, brazing-iron, etc., can be heated advantageously by electricity, and such an equipment has been put in the shops of Prof. Jackson's college.

The test of the electrical flat-irons showed that not only is there a saving in time, but the severity of labor is much lessened. A small flat-iron of 2 or 3 amperes attached to the ordinary lighting fixture in a dressing room is a great convenience, and with an electric tea-kettle and curling-iron are destined to become essentials in the modern home.

Concerning the questions whether the use of electricity had proved satisfactory in its operations in the cooking tests described, the housekeeper in charge said: "The instruments were excellent in every respect. We were able to cook more rapidly, to keep the heat at just the right point, and could readily prevent over-cooking or under-cooking. While we were using electricity every dish was perfect. When I think of these advantages and of the cleanliness and convenience of the utensils, I sincerely hope that some of them at least may be retained in the house permanently."

The general results of the tests were of such a nature that Prof. Jackson is warranted in the belief that if central-station managers would more generally introduce exhibition equipments of these domestic utensils, a new call on their station capacity would develop, of which the larger proportion would be during the light-load periods.

THE ENCLOSED ARC LAMP.

In a paper by Messrs. W. H. Freedman, H. S. Burroughs and J. Rapaport read at the Eliot meeting of the American Institute of Electrical Engineers, the results of exhaustive experiments on the enclosed arc lamp were given, of which the following is an abstract.

All of the enclosed lamps now on the market work on the same general principles. They are placed singly across the ordinary incandescent-lighting circuit, and are regulated to take, approximately, 80 volts across the arc, the rest of the potential being consumed in the regulating solenoid and extra resistance. The standard current is 5 amperes, the arc being about five-sixteenths long. The carbons burn nearly flat instead of taking the conical and crater shape of the open arc. The carbon ends burn flat on the top or positive carbon, the lower or negative one becoming slightly convex. The arc itself does not remain in one spot, but wanders all around the flat ends. The experiment was tried of rounding the ends slightly, but the carbons burned flat again in a very short time.

The current passes through an extra resistance, the solenoid and the carbons, in series. When no current is passing the carbons touch; the moment the current is thrown on, the core is drawn up, carrying the positive carbon by means of a friction clutch. This current is usually carried to the upper carbon by means of two brushes pressing on this rod. As the carbons wear away, the armature of the solenoid gradually descends, the current remaining practically constant whatever the position of the plunger, until it reaches the stop that releases the carbon from the friction clutch; the upper carbon then falls and strikes the lower one, when it is immediately picked up again. This process occurs, however, at comparatively long intervals as the core has a play of 3/8 in. to 1/2 in. before the stop is reached. The positive carbon wearing away at the rate of .05 in. approximately per hour, and the negative at half this rate; there will consequently be from five to eight hours between the times of the resetting of the core to its top position. The open arc lamp feeds about fifteen to twenty times as much, allowing a consumption of 1 in. per hour.

The simple regulating mechanism for the enclosed arc lamp has a very great advantage over that of the ordinary open arc lamp, to which latter the series mechanism is not applicable for the reason that a given variation makes a large proportional change, which defect is obviated by using a long arc. The normal voltage across a 5 ampere enclosed arc is 80, which gives 400 watts expended on the lamp; 72.7 per cent. of the energy supplied to the lamp is spent at the carbon points, the remainder being wasted in the extra resistance. Eighty to 95 volts seems to be as high as is desirable for the best regulation. As to the saving by use on a circuit of lower than ordinary voltage, some experiments showed that for every 100 lamps on a 115-volt circuit, 113 can be run on a 100-volt circuit. In experiments with seven lamps the initial current ranged from 6.75 to 12 amperes, the average current in the latter case being 5 amperes and in the former 5.15.

Comparing the life of the enclosed and open arc lights, the latter requires two carbons for each trimming and lasts six or eight hours; the enclosed arc requires to be trimmed about one-fifteenth or one-twentieth as often and each retrimming costs less. Although the cost per thousand for carbons of the same size is greater for the enclosed arc, being $25 for 12 in. $\times \frac{7}{16}$ in. carbons, only one is required for retrimming; while the open arc requires one 12 in. $\times \frac{7}{16}$ in. carbon, costing $18.70 per thousand, and one 6 in. $\times \frac{7}{16}$ in. carbon, costing $8.30; therefore 1000 trimmings cost $23 for the enclosed lamp against $27 for the open arc.

With an opal inner globe the measurements of candle power were 152 at 20 degs. above the horizontal, and a maximum of 1050 at 40 degs. below, and 734 at 70 degs. below the horizontal, the mean hemispherical candle power being 770. The opal globe cuts off at least 10 per cent. more light than a clear inner globe. The amount of light cut off by the outer globe varies according to the angle of the ray for a given globe, as well as for different globes, the actual figures often being 30 per cent. to 40 per cent. for a globe, the highest value observed for any globe being 50 per cent. With Blondel's holophane globe, the light was reduced only 9.2 per cent.

The conclusions of the candle-power test are as follows: For both inner and outer clear glass globes the watts per candle were about .5; with opal inner and clear outer globes the watts per candle were .56 to .60; with both inner and outer opal globes, the watts per candle were .9 to 1; the efficiency with the holophane globe was but little less than with the ordinary clear outer globe. The amount of light cut off by deposits on the inner globe increases with the length of the run, and differs for different horizontal portions of the inner globe; it was found to vary from 14 per cent. to 60 per cent. for different parts of the globe and for different lamps.

The advantages of the enclosed over the open arc light are enumerated as follows: Long life and consequent saving of carbon, of trimming expenses and annoyance from renewals; pleasant light, free from hissing and spluttering, and with very little flickering; absence of flying dust and sparks, with fire-proof qualities resulting from the use of two globes; lack of danger on account of low potential; no need of an automatic cut-out; simplicity of mechanism and less need of repairs.

ELECTRIC METERING FROM THE CENTRAL-STATION STANDPOINT.

In a paper read at the Eliot meeting of the American Institute of Electrical Engineers, Mr. Caryl D. Haskins read a paper in which the electric meter was considered from the standpoint of the central-station manager. The fact that a meter will start on 1 per cent. of its regular capacity is stated to be in reality no sure criterion of the accuracy of that meter, even on light loads; and that a meter that will run within 5 per cent. of zero error on 5 per cent. of its rated capacity may really be a much better meter, even though it will not run at all on 1 per cent. of its rated capacity, than one which will run at 1 per cent., but in regard to which no evidence is at hand as to the percentage of accuracy at reasonably low loads.

Ability to start on very light loads, while certainly an indication of merit and an important point, is not nearly so important to determine as is the lowest load at which a meter begins to register with fair accuracy. In considering the question of accuracy,

therefore, the first two steps should be to determine the accuracy of the meter by actual measurements at full and medium load and also at a reasonably low load, say, for example, at 5 per cent. of the meter rating. Low-load accuracy is of vital importance from the fact that in the average central station in the neighborhood of 15 per cent. of the total output is for one and two-lamp loads.

A meter should also give accurate results for brief periods on overloads, and should be accurate irrespective of the power factor, for a company which insists upon charging for motor loads on the basis of volt-amperes will render itself unpopular. It is also important that meters should be equally accurate on any shape of alternating-current wave, but many meters now on the market fail in this particular. The same consideration holds good with frequency.

Summing up, the following points should be investigated with care: Ordinary volt-ampere accuracy; accuracy on inductive loads; accuracy for varying wave forms; accuracy on overload; accuracy on varying frequencies; influence on accuracy of variations of temperature, barometric conditions and humidity.

The two chief factors which have influence on mere mechanical life of meters are the weight of the moving mechanism and its speed. A low-speed meter is usually the best, low speed being more conducive to long life than light weight in the moving mechanism. More important than either consideration, however, is the quality of the material used at points of friction and the ease with which the parts subject to friction can be renewed. It is very necessary that the pivot jewel should be in some way cushioned, for vibration, which is very harmful, cannot always be avoided.

Among the methods enumerated as commonly practiced in tampering with meters are the following: The placing of large masses of iron in proximity to the case—which practice, however, is falling somewhat into disrepute since it has been discovered that there is a class of meter which is thereby accelerated; disturbing electromagnets drawing their energy from the circuits under measurement are not now uncommon; meter covers and bases are drilled, and wires, broom straws and the like introduced, and covers are even pried up and a live colony of spiders introduced. A clever apparatus has also been used for injecting fine iron into meters by means of a bellows.

Meters should not be installed on the motor side of the controlling switch, as this not only exposes the apparatus to the full force of the field discharge, but also results in the constant cooling and heating of the potential winding, which causes expansion and contraction, resulting in chafing and weakening of the insulation and also weakening of the wire itself at the turns, thus opening a path for a final breakdown, either by lightning or a field discharge.

It is strongly recommended that fac-simile charts be used in taking the readings, the chart being roughly marked in pencil to indicate the position of the hands at the time of the visit, and the actual readings made at the office by one person who is an expert in meter reading.

It is advised that in changing from a contract to a meter basis, the time of changing should be in the spring and not in the winter months, as the increase in bills, if any, will be much more apparent during the latter season. A case is quoted of a prominent Western lighting company which, as the months grow darker, has its meters read a day or two earlier each month; as the year progresses to the period of lighter days, the months were lengthened, the tendency of this being to even up the bills and yet do no injustice to the customer.

The use of station meters is recommended since they furnish an absolute check upon coal and water consumption and engine and dynamo efficiency, and a ready means for comparison between station output, customer meter indications, line losses and leaks.

If two-rate meters are used, the increased proportional speed for the higher rate should be dependent purely upon the occurrence of the station peak and should bear no relation whatever to the local peak itself, as this would discourage the use of current at periods favorable to the central station.

A PRACTICAL METHOD OF GENERATOR VARIABLE OVER-COMPOUNDING.

BY REESE HUTCHISON.

As is well known, an over-compounded dynamo delivers a practically constant E. M. F. at the terminals of a line, at all loads. It may be applied to any circuit intended for a similar voltage, and after once its value of over-compounding has been adjusted to the circuit, it will deliver the required steady voltage at the desired point. It is the object of this article to briefly describe a simple practical method for rendering the compounding variable for different conditions.

By varying either the number of turns of the series field or the amount of current that flows through it, the E. M. F. of the machine may be varied. For the benefit of those who do not thoroughly understand the principle of this change produced by varying either of these quantities, it will be briefly explained.

Suppose we have an electromagnet of twenty turns of large wire, and pass 10 amperes through it. The magnet develops a certain strength. Now take off five turns of the wire, and pass the same current through the remaining fifteen. The strength of the magnet is decreased. Wind the five turns back, and decrease the current to 8 amperes. The strength of the magnet is decreased also. So we see that by varying either of these quantities, the strength of the magnet is proportional to the two quantities, which, combined, are called ampere-turns.

If, instead of reducing the supply current to 8 amperes, we connect a piece of small wire across the terminals of the magnet, part of the current is shunted past, and the magnetic strength diminished. Obviously, by connecting a variable resistance across the terminals, the magnetic strength may be varied at will.

By applying this principle to the compound dynamo, we find that if we shunt part of the current past the series field winding, we decrease the voltage of the machine. A variable shunt will produce a variable E. M. F. at will.

Having thus understood the principle, let us apply it practically to our machine. It is, say, a 110-volt shunt dynamo. For the sake of convenience, and allowing a large margin for varying conditions, compound it for 134 volts. By referring to the article by Prof. A. F. McKissick in the November issue of

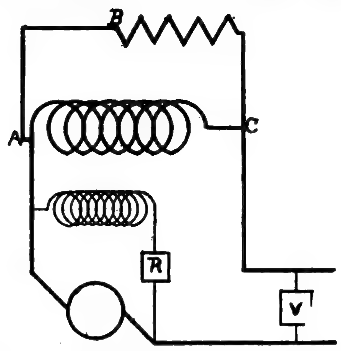


FIG. 1.—DIAGRAM OF CONNECTIONS.

this paper, a most excellent method of compounding may be used.

By any good method, compound for 134 volts. Then we have 24 volts margin to allow for varying conditions. At 134 volts and full load we have, say, 200 amperes in the series field. To determine the size wire for the 110-volt shunt, we find that 24 volts is $\frac{17}{100}$ of 134, and $\frac{17}{100}$ of 200 amperes = 34 amperes. Hence, for the 110-volt shunt, the wire must carry 34 amperes. A No. 7 B. & S. wire—German silver or copper wire—will answer, preferably the former.

With dynamo generating 134 volts and full load on, connect one end of the German silver wire to the beginning of series field (*A*, Fig. 1). Bare a small place in the in-

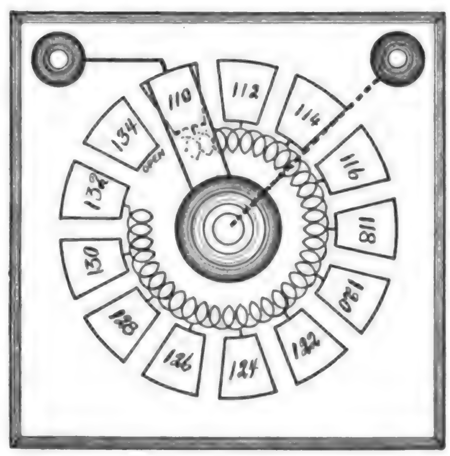


FIG. 2.—SHUNT BOX.

sulation of the wire at *C*. Connect a voltmeter, *V*, to the mains near the generator, and experimentally determine the length for the 110-volt shunt. Mark this place on the wire and test for the 112 point, and so on up to 132, the shunt-circuit being open at 134. At each mark solder a lead of stout wire. The length, *A-B*, may be cut off and used as a connection from the shunt-box to the proper points on the machine, as this is the 110-volt shunt, and a constant quantity. The length, *B-C*, is coiled to fit a suitably constructed box, as shown in Fig. 2, which also explains connections. The completed box may be attached to the frame of the machine, in an accessible position.

THE FUSE AND THE CIRCUIT BREAKER.

BY PROF. W. M. STINE.

Conservatism is an admirable thing when applied with discretion, yet when meritorious changes are suggested, it too often shades off into resisting prejudice. A conspicuous instance of these qualities was developed against the introduction of the alternating current; and now the same tendency is being manifested in a prolonged discussion which has suggested the caption of this article.

Historically it is difficult to determine where and by whom the fuse was first employed to protect electrical circuits. Ever since the discovery of the Leyden jar, it has been a favorite experiment to deflagrate pieces of metal. With the advent of the galvanic battery the thin sheets of foil gave place to more or less stout wires. Edison is often credited with being the first person to employ the fuse, but its use, in reality, antedates his experiments. That it has been a most important factor in the development of electrical power transmission and electrical lighting, it is true; but when one considers that the various systems of arc lighting were developed without its use in them, it has by no means been the critical feature of electrical development. On the other hand, the magnetic circuit breaker in some form or other has been in use almost from the very inception of modern electrical development.

A number of recent writers have been to considerable pains to demonstrate that the blowing of a fuse being a heat phenomenon, it can be accurately gauged, and will under given conditions act with entire regularity. A peculiar feature of these articles has been the entire absence of data. Scientifically, an opinion without the data upon which it is based, is entitled to due respect, but can never carry conviction. In view of this, the writer can only refer to a number of articles bearing on this subject in which he has presented considerable data covering the operation of the fuse and the circuit breaker. —these must serve as a basis for any statement which follows. Incidentally, his investigations have extended through thousands of tests on both fuses and circuit breakers.

As a general statement, both devices are excellent, but they must be used with judgment and an intelligent knowledge of their limitations.

The fuse wire has been very thoroughly investigated, almost more so than any other electrical device. The proper view to take of it, is that it forms an element of the conducting circuit, in which the resistance is relatively large in order that the $C^2 R$ loss shall be proportionately high; its fusing point should be so proportioned to the circuit it is designed to protect that it shall melt before the conductors, or before the insulation breaks down. It is also clear that the action of the fuse comes under the well-known laws of thermodynamics. Given a certain set of conditions and the blowing of a fuse can be accurately defined by an equation in which the influencing conditions will appear as constants. For example, take Preece's well-known formula

$$c = a\,d^{\frac{3}{2}}$$

in which the constant, a, has a value descriptive of the ordinary metals, and which for copper is sometimes stated to be 2530. There is no difficulty here; given a set of conditions and adhere to them rigidly, and the fuse under test will blow with extreme regularity. This statement cannot be too strongly insisted upon. The difficulty is not here; it arises with the variation and obscurity of the conditions met with in practice. For instance, assuming the liberty of reference to data which will shortly be published, Preece's law undergoes a marked modification when one condition is changed —the time in which the fusing shall occur. The exponent, which above is 1.5, varies from 1.2 to 1.8, according as the fuse is blown very slowly or rapidly, and the constant for any one metal varies with the length of the wire employed.

From our investigations, the regularity of the blowing of a fuse was interfered with by a variety of conditions; amongst these were: (a), the length of the fuse; (b), the oxide film or coating; (c), the condition and mass of the terminals; (d), contact with foreign substances; (e), whether the fuse was exposed or open freely to the air. The experiments of the writer substantiate the lengths prescribed by the fire underwriters. If anything, these lengths should be increased about 25 per cent. This is one of the main causes for the unreliability of fuses. If the diameter and length be intelligently selected for a given fuse, it may be depended upon to act with approximate uniformity on all except momentary or impulsive currents.

The oxide film which always forms, even when the fuse blows quickly, and to a very great extent when the fuse is heated up slowly, forms a tube which retains the molten metal and prevents the rupture of the circuit. In small wires this feature is apt to remedy itself to a certain extent. The oxide-coated, hot wire has its resistance very largely increased. As a consequence, the heat generated in it is proportionally increased, and rupture will occur provided at the same time the current is largely increased over the rated capacity. As the oxide tube is strongest when truly cylindrical, a large fuse wire will carry an abnormal current without rupture provided it is a round wire. As a rule for heavy circuits, 25 per cent. excess of current carried for a long time would be disastrous. The practice then, of employing ribbon for large fuses, in which case the film is relatively much weaker, is a good one. For this reason too, large fuses if made from round wire should consist of wires in multiple not exceeding about ⅛ in. in diameter.

Short fuses are unreliable mainly through the cooling effect of terminals, but this is eliminated when the fuses are of sufficient length.

When a portion of the fuse rests on porcelain or other foreign substance, local cooling results, the oxide film is strengthened by being supported, and the carrying capacity of the fuse is enormously increased. Recently fuses have been placed on the market contained in a tube packed with sand, or other non-conducting substance. Such fuses can be properly rated and so far as the cooling influence is concerned, will blow with uniformity. These fuses are excellent, in that they diminish fire risks.

The writer's experiments have shown they possess one striking weakness over open fuses. Being supported throughout their length, the metal melts and even a very thin film of oxide suffices to prevent rupture. With creeping currents and an absence of mechanical jar, they will carry an overload in excess of 50 per cent. of their rated capacity. For relatively great impulsive currents they open the circuit with satisfactory regularity.

A fuse placed in a covered receptacle will always have its carrying capacity increased; for small fuses it may amount to several fold.

As a summary, not of opinion, but of the evidence from accurate tests, a fuse of the proper length, and exposed to the air, properly placed in its receptacle, and mounted on copper terminals will do excellent service, both as regards regularity and reliability, except where small time constants may be of importance. But constructed as it may be, it will always have one fault—its time constant is large, and except for abnormally excessive currents, will be slow in opening the circuit. Yet this peculiarity renders the fuse of especial service in certain cases where a temporary overload is a necessity, and the apparatus is constructed to withstand it.

The fuse has its use and merits, and will doubtless always remain in good engineering practice. But there are very many places in which its function is better fulfilled by a magnetic circuit-breaker. Neither device should be employed to the exclusion of the other. For closet work the fuse is an excellent device, and it would not be wise to replace it with the circuit- breaker. On the other hand, it should be excluded from switch-boards; for in saying this, one must accept the evidence submitted by the underwriters as well as experimental data.

In general practice a motor should be protected by a magnetic circuit-breaker. The rheostat controlling the motor, except in special cases, should be designed so that the starting current shall in no case exceed the normal rating for the motor. Current in excess of this, even should it not injure the commutator or insulation, will greatly decrease the starting torque by its armature reaction. A prominent firm in Chicago, one of the largest manufacturers of rheostats, has stated to the writer that it designs its starting resistances so that at no time will the starting current exceed the normal rated current for the motor. Such intelligent design as this obviates all objection to the use of the circuit breaker with a motor.

The writer has a 20-HP motor which formerly was protected with a fuse. On two occasions, owing to a fault in the stop-cock of the oil reservoir at the pulley bearing, the box heated and melted out the babbitt, letting the armature down on the field. The fuse eventually opened the circuit, but not until considerable damage had been done to the armature. In such a case as this, a time constant in excess of a second is a disadvan-

tage. The fuse is now discarded in favor of an accurately set circuit-breaker. This has never yet given trouble when starting up the motor, and as the motor operates a large number of wood-working machines and several long lines of shafting, it can fairly be taken as a typical case.

Finally, the evidence from tests of a large number of makes of circuit breakers is that their opening does not vary to exceed from 3 per cent. to 5 per cent., and is practically the same for creeping and impulsive currents, while their time constant is a minute fraction of a second.

CIRCUIT BREAKERS VS. FUSES.

BY TOM. W. BEVAN.

I cannot understand why Mr. Cutler should be so determinedly opposed to the automatic circuit breaker. He gives a very graphic description of a switch-board man "chasing himself up and down the board"—I suppose he means when there is trouble on the line. Now, if that man had fuses to look out for instead of circuit breakers, he would need another man besides himself to "chase himself up and down the board," and there would be a constant delay in changing fuses with possibly some damage done also. If this should happen during a snow-storm, on one of the suburban lines, about 6 P.M. (the most likely time), the passengers would be worked up to such a voltage that no fuse man would dare venture in the cars.

Again, he says that he "will guarantee to connect such a fuse (as he describes, and similar to fuses we tried on the West End Railway, Boston, years ago), in series with any circuit breaker ever yet put on the market, short-circuit 220 or 500 volts through these devices and blow the fuse." Very good; that means one operation and one fuse. He probably would, but I venture to say that neither Mr. Cutler nor any other man will guarantee the same result every time on that circuit, if a railway feeder. I maintain that we do not want a fuse in a railway power station except for the light circuits.

The fuse is undoubtedly much abused in some lighting stations, mostly by new or careless attendants, but I think that if the man who is always careless when putting in fuses, was put as inspector on a route which gave him some fifty or seventy-five transformers during a few rainy or snow-stormy nights, he would soon begin to think for himself, or inquire the best way to put in a fuse.

But let us go back to the power house. This was a vexed question with Mr. R. C. Brown, the late assistant master mechanic of the West End Railway (who is now, I understand, general manager of some other roads), and I doubt, if there is another man in the country who has studied the fuse and circuit breaker question from a practical standpoint and under every-day working conditions, more than he has, and his decision was in favor of the latter. If Mr. Cutler should ever be fortunate enough to meet this gentleman I am sure he can obtain from him some valuable information. We have General Electric and Westinghouse circuit breakers in use on the West End Railway, and I don't want a fuse in any of the stations. I feel confident that any one or all of our circuit breakers will respond in case of trouble quicker than Mr. Cutter could say "*Fuse*," and at all times. I don't believe that Brother Cutler means one-half what he has said against the circuit breaker, but he has made some statements very misleading to the public.

THERMO-ELECTRIC BATTERIES.

BY PROF. W. A. ANTHONY.

In Mr. Reed's reply to my communication in your last issue he says my contention is not clear to him. The ground upon which he bases his contention is certainly not clear to me. In his list of possible reactions by which the oxidation of the carbon in the Jacques cell to carbon dioxide by the electrolyte may take place, he omits the reduction of $Fe_2 O_3$ to $Fe O$, which is a possible reaction, and entirely ignores the effect of the oxygen forced into the cell at the other electrode.

My contention is that with oxygen present ready to combine with the reduced ion, that ion is never actually free but simply passes from one molecule of oxygen to another. In considering the action of the cell, we have no right to base an assumption upon the action at one electrode alone. We have on the one hand carbon, having at the temperature of the electrolyte a powerful affinity for oxygen, and on the other hand oxygen having a powerful affinity for the other ion of the electrolyte. We know that in the sum total of chemical action that takes place, energy is evolved within the cell more than sufficient to account for the electrical energy developed. In other words, the cell would, if sufficiently protected by non-conducting coverings, keep itself hot after the action once commenced—that is, after the temperature was once brought to the point necessary to begin the action.

Mr. Reed says the reactions he describes require energy. Very well, the energy is there within the cell, where oxygen is ready to combine with the freed ions molecule by molecule, before even those molecules have united to form a physical mass, and my contention is that the electrolyte does undergo decomposition as in any other galvanic cell, that decomposition being determined by the affinities at both ends of the line.

I contend that in determining the energy evolved by any reaction we have only to consider the final result and not the intermediate steps, and I repeat that in the final result in the Jacques cell, there is energy enough and more than enough to account for the electrical energy developed. In view of this it seems to me absurd to say that the action is thermo-electric and that the energy is derived from an outside source.

In the Grove cell the E. M. F. is not the E. M. F. due to the action at either one electrode, but the sum of the E. M. Fs. due to the resistance of both. In the gravity cell, consisting of zinc, zinc sulphate, copper sulphate, copper, the zinc cannot reduce the zinc sulphate with which it is in contact, copper could not be deposited from the copper sulphate on the copper, but in the sum total of the reactions, which consists of a substitution of Zn for Cu at the plane of separation of the two solutions, the solution of the Zn at the zinc electrode, and the deposition of Cu at the copper electrode, an E. M. F. is produced and energy evolved.

With platinum plates in acidulated water an E. M. F. of some 1.4 volts is necessary to produce a visible evolution of gas, but $\frac{1}{1000}$ volt will maintain a continuous current between the plates, the H and O never appearing as gases but going into solution in the liquid to recombine wherever they may meet. So with platinum plates in $Cu\,SO_4$, an E. M. F. of more than a volt is necessary to cause a reasonably rapid deposition of copper, but substitute a copper for the platinum anode and deposition will go on rapidly with a fraction of a volt.

I give these examples to show that not only the energy, but the E. M. F. involved, depends upon the action at both the electrodes and not upon that at one alone.

While it may be true that a certain amount of energy is necessary to cause the decomposition of an electrolyte with the aggregation of the ions into physical masses, it by no means follows that the same energy is required when some other substance stands ready to seize upon the molecules of the ion as fast as they are liberated, forming a new compound with the evolution of energy.

In regard to the hot and cold pieces of iron in an electrolyte, I have never supposed that a continuous evolution of energy could occur, the composition of the electrolyte remaining unchanged. If iron is dissolved at one electrode it does not follow that iron would be deposited at the other.

I have not myself performed these experiments, but I see no reason for Mr. Reed's explanation of his results. *Is* the cell an inexhaustible source of electrical energy? With the heat maintained and one electrode kept cool, *will* a continuous current be developed without change in the electrolyte? If not, then there is no evidence that the current is maintained at the expense of heat energy supplied from without. The experiments of the German authors, to which I before referred, show that iron is dissolved and is oxidized in the bath, and that the observed E. M. F. depends upon the state of oxidation. My belief is that when the matter is fully investigated it will be found that the energy of this cell also comes from chemical action within the electrolyte, which is partly absorption of oxygen from the air, that that action, whatsoever it may may be, will finally exhaust the electrolyte, which will then have to be renewed as in any other battery.

To the Editor of American Electrician:

I will try once more to make clear to Prof. Anthony the reasons for my oft-repeated statement that the reaction in the Jacques cell is not galvanic.

In the August issue of the AMERICAN ELECTRICIAN, Prof. Anthony maintained that "no substance is reduced and no energy is required for that purpose." He said further in that connection, "The cell at the beginning contains carbon and the fused alkali. The carbon is oxidized and the alkali is changed to carbonate. Both opera-

tions evolve energy." I interpreted this to mean that the carbon is oxidized directly by combining with free oxygen and not with oxygen derived from the reduction or decomposition of the electrolyte, and that the electrical energy came directly from the energy of this combination and of the subsequent combination of the product of that reaction with the alkali.

My contention in the same issue, was and is that such an arrangement would not constitute a galvanic element; that in a galvanic element there is necessarily an electrolyte through which the current passes and that the electrolyte necessarily undergoes binary decomposition into two constituents which appear at the terminals of the electrolyte; and that in a galvanic cell the energy of the chemical reactions *within the cell* must be capable of spontaneously effecting the decomposition without the absorption of external heat. I stated also that there was no electrolyte in the Jacques cell which could undergo such decomposition without absorbing external heat, meaning that the total energy of combustion of the carbon oxidized in the cell, would not be sufficient to cause decomposition of any compound in the cell *without the absorption of external heat.* In support of this I mentioned the five possible reactions between carbon and the various constituents of the cell which could result in the oxidation of carbon to CO_2, none of which could take place without the adsorption of external heat in addition to the energy supplied by the oxidation of the carbon. This being true, I maintained and still maintain that no decomposition of the electrolyte, and hence no galvanic action, could even commence. If the action could not commence how could it proceed?

Prof. Anthony now abandons his former theory and admits—with some vehemence—that there must be binary decomposition of the electrolyte. In that he is undoubtedly correct. But he says, "Very well, the energy is there within the cell," etc. It may easily be shown by the combination heats of all the substances present, as often repeated by me, that the energy is *not there*, within the cell. But this Prof. Anthony entirely ignores, though it is a matter of fact established by abundant authority.

The above communication from Prof. Anthony shows where his mistake is, and explains his difficulty in understanding why galvanic action in the Jacques cell is impossible. He says, "We know that in the sum total of chemical action that takes place, energy is evolved within the cell more than sufficient to account for the electrical energy developed. In other words, the cell would, if sufficiently protected by non-conducting coatings, keep itself hot after the action once commenced—that is, after the temperature was once brought to the point necessary to begin the action." He evidently supposes because the oxidation of the carbon furnishes energy enough to account for the electrical energy developed, or to keep the cell hot, that it must, therefore, furnish enough to decompose anything that may be in the cell. This is the fatal mistake. There is no relation whatever between these two quantities. The quantity of electrical energy developed in the Jacques cell was small and might have been much smaller, but the quantity required to decompose the electrolyte is large. The electrical energy, as claimed by Dr. Jacques, was only about 80 per cent. of that contained in the carbon, while that required for any possible chemical reaction exceeds that contained in the carbon. This fact has been repeatedly ignored by Prof. Anthony in all his numerous communications on the subject, and the reason is now apparent. The question at issue is not whether the Jacques cell evolved less electrical energy than that contained in the carbon consumed, but whether it could be accomplished through decomposition of the electrolyte without absorption of external heat, that is, by galvanic action, the same as that of the Daniell cell.

One more question deserving of notice is raised in the above communication by Prof. Anthony. He claims the possibility of the chemical reaction being a reduction of Fe_2O_3 to FeO. If this were possible it would not help his theory, as that reduction would require 12.6 units of energy more than the carbon contains. The reaction would be as follows:

$$C + \overset{382.4}{2\,Fe_2O_3} = \overset{97}{CO_2} + \overset{272.8}{4\,FeO} + 12.6$$

But there are several reasons why this is not possible:

(1). Carbon at the temperature of the Jacques cell does not reduce ferric oxide to ferrous oxide, but to metallic iron) the reduction being effected, as in all other reductions by carbon, only at a temperature at which it can absorb the heat necessary for the reaction).

(2). Ferric oxide, as such, is not soluble in alkaline hydrates at any temperature, but dissolves only by changing to an alkaline ferrate. Isolated particles of a solid body suspended in a liquid could not constitute the electrolyte of a galvanic cell. It must be a continuous body electrically connecting the terminal or electrodes.

(3.) Prof. Elihu Thomson has found by experiment (vide Jour. Frank. Inst. Nov., 1896, page 385) that metallic iron and not ferrous oxide is formed in the cell at the cell wall.

Is it not better to accept established facts than to go so far in search of a remote possibility of supporting an improbable theory?

In reference to the modified cell, containing an iron instead of a carbon rod, the alkaline ferrate is the most easily reduced of any electrolyte or compound in the cell and if an electric current passes through it, the amount of iron reduced on one electrode must be the equivalent of the amount oxidized at the other. C. J. Reed.

Philadelphia, Pa.

MOORE SYSTEM OF VACUUM-TUBE LIGHTING.

When Mr. D. McFarlan Moore, after a thorough study of the subject, came to the conclusion several years ago that the solution of the vacuum-tube lighting problem lay in the breaking of an inductive circuit in a vacuum, he almost immediately decided that it could be done most advantageously by the use of a rotary and not a vibratory motion. He also realized, however, that mechanically a vibratory motion is far easier to construct in a vacuum than a rotary one and that such a form of vacuum make-and-break would have a large field of usefulness; besides, immediate results were very much desired, and he therefore decided to demonstrate the feasibility and practicability of the vacuum make-and-break by means of the vibrator, which he therefore perfected first. Work was nevertheless continued on the rotary make-and-break motion, and the accompanying figure shows the form now in use.

The apparatus used last year by Mr. Moore in lighting the hall of the American Institute of Electrical Engineers and, later,

MOORE VACUUM-BRAKE ROTATOR.

in lighting the stage on the occasion of his lecture before the National Electric Light Association and, also, during the Electrical Exhibition, consisted of three large wooden boxes, each 4 ft. 6 ins. long, 14 ins. wide and 10 ins. deep, which contained nine vibrators each. The great advance that has been made is rendered at once apparent by the illustration here shown, which apparatus was used to light the hall of the Moore laboratory during the evening of his last exhibit, on May 27 of this year.

Mr. Moore says that it will not be long before he will give an exhibition with the new form of the make-and-break apparatus, which will eclipse any of his previous exhibitions, his system of vacuum-tube light-

ing being claimed to be now in such a condition as to be ready for commercial competition with incandescent lighting.

NOTES.

Illinois Manufacturers' Exposition. The exhibition of Illinois products to be held in the Studebaker Building, Chicago, from Sept. 1 to Oct. 1, includes electricity as a section with three classes, while electric railways form a class in the transportation section. The object of the exposition is to foster home trade, the prospectus stating that a million dollars a day are sent out of Chicago alone to purchase articles manufactured without the state. One of the patrons of the exposition is Mr. Samuel Insull, president of the National Electric Light Association.

Effect of Moisture on Insulation.—In a paper read before the Eliot meeting of the American Institute of Electrical Engineers, Messrs. Putnam A. Bates and Walter C. Barnes gave the result of experiments undertaken to discover the discrepancy between the results of former investigators on the effect of heat on insulating materials. It was found that the differences could be ascribed solely to the amount of moisture contained in the material and its opportunity to escape; and furthermore, every time a specimen cooled, the resistance increased to a value much above any resistance it possessed before, provided it was kept from absorbing moisture.

Engineers' Club of Chicago.—The newly organized Engineers' Club of Chicago has settled into quarters in the Fisher Building of that city. The officers are M. D. Kasson, president; C. W. Naylor, C. DeWitt Wines, B. W. Thurtell, James McDonough and T. J. McMasters, vice-presidents; Lewis M. Ellison, secretary. Aside from its social object, the club will have a professional one, including the reading and discussion of papers and excursions to examine objects of scientific interest. The full membership is not limited to engineers, as in the case of the New York Engineers' Club, but includes those actively engaged or interested in the sale of machinery and supplies for power generating or transmitting plants.

Another Huge Order.–Westinghouse, Church, Kerr & Company have obtained the contract for the engineering equipment of the new Boston terminal station, the amount of the contract being considerably over $500,000. The engineering equipment comprises signaling and switching, power house equipment, electric arc and incandescent lighting, elevators and lifts for passenger, freight and baggage service, heating and ventilation, ice making for car and restaurant use, etc., refrigeration for restaurant, kitchen and storage boxes, cooling water supply for head house, car heating in train shed, storage and express yards, air-brake testing, fire protection, disposal of drainage from water-proof structure, frost protection for roof conductors and steam and hot water supply for head house. The electrical generating plant will consist of Westinghouse multipolar dynamos direct coupled to Westinghouse compound engines.

Electricity in a College Course.—In a paper read by Brother Potamian of Manhattan College, New York, before the convocation of the University of the state of New York, the claims of electricity were urged as part of a regular college course. While due credit is given to literary, historical and philosophical subjects toward supplying needful discipline to the mind, and scholarship, they leave the senses untrained and the mind uninformed about matters which are of cardinal importance in the round of every-day life. While in undergraduate college courses a place is assigned to physical science, electricity is one branch which deserves greater attention in such courses than it usually receives, as a means of mental discipline and a subject of information. One of its advantages is that it lends itself more easily to experimental illustration, and as possessing a special fascination it affords a needed and refreshing relaxation from the prolonged concentra ion of the mind on the more arduous literary and philosophical studies of the senior year. As to the time allotted, Brother Potamian considers experience indicates a minimum of two hours a week through the year, and believes it is utterly impossible to treat the subject at all satisfactorily in less than eighty lectures. Even then, he concludes, the matters dealt with must necessarily be non-technical and of an elementary nature; but they can easily be made to include not only the outlines, but all the more essential features of electricity and her inseparable twin sister, magnetism.

Trans-Mississippi Exposition.—Prof. R. B. Owens, of the University of Nebraska, is in charge of the electrical section of the Trans-Mississippi Exposition, which section promises through his efforts to form one of the most attractive features of the exposition. He has succeeded in interesting the larger manufacturers of electrical machinery, many of whom will install exhibits, and an endeavor will be made to have the several national professional and commercial electrical associations hold their annual meetings next year at Omaha during the time of the exposition. The practical experience of Prof. Owens in electrical affairs will count in his new position, which gives him full charge of organizing and superintending the electrical department. This has been practically insured so far as the American Institute of Electrical Engineers is concerned, by a vote at the recent general meeting of that body at Eliot, Me., which the council in all probability will confirm. Prof. Owens is a native of Maryland and obtained his education in that state, studying under Dr. Louis Duncan at the Johns Hopkins University. In 1891 he obtained the post-graduate degree of E. E. from Columbia University, being a member of the first class in the United States to receive that degree. In the intervals of his school preparation the young student acquired a fund of practical knowledge, first with the old Baxter Motor Company, then with the Excelsior Company, and also as superintendent of a Thomson-Houston station at Greenwich, Conn. Shortly after receiving his degree, Mr. Owens was appointed adjunct professor of electrical engineering in the University of Nebraska, and in 1894 he was made full professor, having in the meantime served as one of the judges of electrical exhibits at the World's Fair. Full charge of the department of electrical and steam engineering was conferred on Prof. Owens in 1895. Prof Owens believes that the technical school should be in close touch with the best practice, and usually spends his summers in work that increases his experience in solving actual, every-day problems. His new duties will not make it necessary for him to sever his connection with the University, and it is safe to say that the electrical department of the Trans-Mississippi Exposition will greatly benefit by his knowledge, experience, reputation and wide acquaintance in electrical circles, both professional and industrial.

Transformer Regulation.—At the Detroit meeting of the American Association for the Advancement of Science, Prof. Frederick Bedell and Messrs. R. E. Chandler and R. N. Sherwood, Jr., presented a paper entitled, "The Predetermination of the Regulation of a Transformer with Non-Inductive Load." To determine the regulation by the method proposed, a wattmeter, ammeter and voltmeter are located in the primary circuit. One set of readings is taken with the secondary short-circuited by a stout copper wire, the primary voltage being adjusted until the normal full-load current flows in the transformer or any desired fraction of it. No other data for obtaining a complete regulation curve is required except the one set of readings above mentioned, and the magnetizing current. If a wattmeter reading is taken when the magnetizing current is measured, the data are sufficient to plot a complete efficiency curve, as well as a curve for the regulation of the transformer. The two sets of measurements then consist of the reading of a wattmeter, voltmeter and ammeter, first on short-circuit with normal current, and second on open-circuit at normal voltage. The wattmeter reading in the first case gives the copper losses; in the second case, the core losses. It is commonly convenient to use the high-potential coil as primary in the short-circuit measurement, and the low-potential coil as primary in the open-circuit measurements. A high-potential supply is not then needed, and as no power is required, except to supply the losses, the complete test of a transformer may be made with an incandescent-lighting circuit for the source of supply, a fifty-light transformer being tested from one 16-CP lamp socket. The total drop is found by laying off in the proper manner the inductive drop, the magnetic leakage drop and the drop due to ohmic resistance. The method is theoretically an almost exact one. Practically it is an exact method and less likely to error than the ordinary method of determining the regulation of a transformer by loading it. The results given in this paper from a series of tests on seven transformers of various makes, show the reliability of the method, the secondary voltage at full load determined by it varying usually less than one or two-tenths of a volt from the voltage as found by measurement on the transformer when actually loaded. The approximate method of transformer testing originated by Kapp, and which is now largely used in this country, gives less accurate results.

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Rontgen Rays.

Some months ago we called attention to the danger that may attend the application of Röntgen rays to the human body, and the accounts that have so frequently of late appeared in the newspaper press lead us to repeat the caution. Cases of extreme suffering have been reported, and it appears to be about time for the medical fraternity to take some action. The human organism is too delicate a structure to be trifled with, and the laws which prevent unauthorized persons from practicing the physician's art should be extended to include the application of Röntgen rays. This would not necessarily imply that only physicians should be permitted to do so, as licenses could be granted, after examination and under suitable restrictions, to competent experts in this branch. Of these, there are several in New York, and as the manipulation of the generating apparatus requires considerable skill, the services of such experts will continue to be of value. If present laws do not cover the case, the amateur experimenter should, be prevented by legal enactment, from immolating victims to his ignorance.

Charging for Inductive-Power Load.

In a discussion on metering at the Eliot meeting of the American Institute of Electrical Engineers, Dr. Bell referred to the desirability of the power factor being taken into consideration in charging for inductive alternating-current load. He stated that some recent plants installed have reached their full capacity on as low as 70 per cent. of their watt rating. The capacity of a generator being fixed by the current passing through its coils, it is obvious that every decrease in the power factor subtracts from the capacity by the amount of the corresponding idle current, such current being due to the inductance in circuit. Mr. Steinmetz agreed with Dr. Bell as to the unfairness of basing the charge under such circumstances on meter readings, which merely register the useful energy consumed and take no account of the value of the idle current, though generator capacity must be supplied for the latter.

The case above noted corresponds exactly with the conditions which the Wright system of charges was devised to meet in direct-current working, and which system would seem to be directly applicable to alternating current motor work. The only doubtful point is in connection with abnormal rushes of current upon starting up or when there is a tendency to get out of step, but these could probably be met by a properly constructed meter of the Wright system.

Eliot Meeting of the A. I. E. E.

The recent meeting of the American Institute of Electrical Engineers at Eliot, Me., was a most enjoyable one, professionally and otherwise, to those in attendance. Though the number of members was small, it included a very considerable proportion of those upon whom the Institute depends for its prestige and the *Transactions* for its value. Of the more practical papers we print abstracts in other columns, reserving Prof. Thomson's paper on a new form of induction coil for another issue. In addition to these, the *Transactions* will be enriched by several papers giving the results of original research with reference to electrical theory and design, and by two engineering papers of high value—on the cost of steam power, and on electric elevated railway traction.

In his paper on the cost of steam power, Mr. Horatio A. Foster does a good service by pointing out how misleading any statements necessarily are that profess to give the cost of steam power without qualification as to the character of the work performed and the size of the plant. This, of course, is no reflection upon the excellent tables of Mr. C. E. Emery, which are accompanied by exact statements of the conditions upon which they are based, but applies to the loose references as to cost of steam power which frequently occur when electrical transmission of power is discussed. In a table given in Mr. Foster's paper, based upon tests of 22 steam plants, the cost of power is shown to vary from .53 cents to 5.6 cents per HP-hour. Of two plants of 129 and 166 HP respectively, the former gave a cost of .8 cent, and the latter, a cost of 1.59 cents, per HP-hour.

The La Crosse Convention.

The recent convention at La Crosse of the Northwestern Electrical Association showed some falling off from the interest which attended previous meetings during the past few years. This was, however, doubtless due to prevailing business conditions, for there was no indication that the Association is lacking in vigor or that the prospect for the future is in any way dimmed. The four papers read, abstracts of which appeared in our issue for August, were admirably adapted, both in subject and treatment, to the occasion. As exhaust steam heating is coming to the front, the paper on that subject by Mr. Thayer was particularly appropriate, while the information it conveyed was of the practical and commercial character most desired by central station men. The same may be said of the paper by Messrs. O. M. Rau and F. A. Vaughn on the constant-potential arc, and that of Mr. R. F. Schuchardt on meters, both being subjects of every-day importance, and treated by the authors entirely from a practical standpoint.

The paper by Prof. Shepardson on 220-volt lamps was one of timely importance, since it gives definite and reliable information concerning 220-volt lamps, in regard to whose efficiency opinions have been at variance. Prof. Shepardson's tests conclusively show that 220-volt lamps are, as compared with lamps of standard voltage, of very low efficiency. Mr. John W. Howell has shown that this necessarily follows, for the reason that the high-resistance filaments of 220-lamps can be subjected to very little "treatment," on account of the effect of such "treatment" in lowering resistance, the coating thereby deposited being of much less specific resistance than the body of the filament. Lacking the necessary thickness, the high-voltage filament must be used at a lower temperature, which results in a lower efficiency. The verdict of Prof. Shepardson on this point, however, does not, he considers, affect the high-voltage system as a whole, his conclusion being that its other advantages are such as to render it superior to both the alternating and low-voltage systems where the proper conditions apply.

The Strassburg Central Station.

In this issue we print a description from an authoritative pen of the new three-phase central station at Strassburg, Germany, the article supplementing three others which appeared in our June issue, describing an American, English and French station, respectively. Of the last mentioned plants, the American station employs the monocyclic system, and among other points is notable for the large extent of territory covered by its service. The English station is remarkable more for the progressive character of its management and the system of charging for its service, than for any particularly novel engineering features; one instructive feature of the Brighton system, however, is the method there adopted of building up custom in outlying districts by the use of the alternating current, changing over to the three-wire distribution when a profitable load has thus been worked up. The French station, at Rouen, employs two systems of distribution — a three-wire, direct-current system fed direct from the station, and outlying sub-stations in which rotary transformers are operated by alternating currents transmitted from the central plant, which in turn feed direct current into the neighboring distributing system.

The Strassburg station is of still another type, three-phased currents being employed, and distributed from feeding points to transformer stations, from which in turn secondary distributing lines are fed. As will be seen, most of the transformer stations are in walled underground chambers; in this connection it may be noted that this disposition of transformers involves no difficulty from dampness, for the reason that by means of the heat from the cases and a suitable arrangement of partitions, excellent ventilation is secured. Among the features of this plant which are of much interest are the gradations in the size of the generating units, the electric railway storage battery auxiliary, the triple-concentric conductors used, the testing system installed throughout the territory covered, and the excellent design of the steam plant. The plant gives evidence throughout of excellent engineering, and many of the details described will furnish much of direct practical interest to our central-station readers.

The Sprague Multiple-Unit Electric-Railway System.

The recent highly successful trials of the Sprague multiple-unit electric railway system at Schenectady will most probably have a vital bearing on the future of elevated-railway traction, for they appear to have amply demonstrated that the system offers ideal advantages for elevated railway service. So far as traffic is concerned, these advantages are the provision of means whereby car units may be run singly or concentrated into trains without detriment to either method of operation, each car being complete in itself and yet, when any number are thrown together, the train immediately operates as a unit. For elevated railway traffic with its great morning and evening load peaks, and comparatively slim travel during some hours, the advantage of this flexibility is obvious, admitting as it does of a perfectly uniform service at all hours—by large trains running on small headway during the busy period and by single cars at short intervals during the lulls, with coupled units increasing and decreasing in number with the rise and fall of traffic. The addition or subtraction of cars from trains is a matter of the utmost simplicity from each car being complete in itself and immediately locking step when coupled, the operation of coupling being itself an automatic one.

From the engineering standpoint the advantages are no less apparent. Instead of the tractive effort being concentrated at the wheels of a single motor car necessarily of great weight, it is distributed over an elevated structure the entire length of a train, thereby decreasing wear and tear and enabling the strength of the structure to be utilized to a maximum. Moreover, by thus utilizing the entire weight of the train a total tractive effort is obtained many times greater than is possible in the case of a train drawn by a single motor car. Lack of published details does not permit of an opinion concerning the details of the system upon which its successful operation depends. In view, however, of the record of Mr. Sprague in other lines as a master of detail, there is every assurance that if any defects appear they will be as efficiently remedied as were those which presented themselves in his pioneer work with the electric motor, the electric railway and the electric elevator.

Thermo-Electric Batteries.

On another page we print a continuation of the discussion between Prof. W. A. Anthony and Mr. C. J. Reed on thermo-electric batteries, and it would seem that the straw has been now so thoroughly threshed out that there is little or nothing left to say—in fact, there having been some repetition already. The controversy started, as will be remembered, by the publication in our April issue of a résumé to date by Mr. Reed on the subject of thermo-electric batteries. Mr. Reed there made a number of statements that were new to a large portion of the electrical fraternity, some of which passed unquestioned, but others were promptly and vigorously disputed.

The statements relating to the Jacques cell and the Case "tin-chromic-chloride" cell were called into question by Prof. Anthony in our June issue. In the same number Mr. Case also took a part in the discussion, but it will be observed he did not deny Mr. Reed's statement regarding the tin-chromic-chloride cell, but called attention to his other cell, for which the claim is made that it oxidizes carbon in the cold. In the July issue Mr. Reed replies to both these gentlemen, since which has been no further discussion on either of Mr. Case's cells. In the August and the present issue, however, are letters from Prof. Anthony and Mr. Reed on the theory of Dr. Jacques' cell.

The discussion has been carried on in a dignified manner on both sides and cannot fail to be instructive to our readers. Scientific discussions carried on in the true scientific spirit are always profitable reading. We are inclined to believe that Mr. Reed has maintained his position, at least so far as his principal contentions are concerned—namely, that the chemical reaction which takes place on the discharge of the tin-chromic-chloride cell does not evolve, but absorbs, energy (which is not denied by Mr. Case); that Mr. Case's other cell does not evolve energy from the oxidation of carbon proper in the cold solution; and that the Jacques cell also gets its electrical energy from some other source than the electrolyzed carbon. We shall continue, however, to hold open our columns to arguments from the other side so long as there are any to present that are not merely repetitions of those already published.

DESIGNS FOR SMALL MOTORS. IV.

ONE-FOURTH-HP MOTOR WITH RING ARMATURE.

BY CECIL P. POOLE.

Of the accompanying drawings Fig. 1 represents the field magnet and a journal yoke. The magnet is of the single-coil type like that last described. The core is of round Norway iron, 2 ins. in diameter and 9 ins. long over all. The ends are turned tapering as indicated by dotted lines, to insure intimate contact with the yokes; the taper is from the full diameter to 1¾ ins. and begins 2 ins. from each end. The pole-pieces are of cast-iron. Fig. 2 gives a plan view, and Fig. 3 a face view of one pole-piece from which all the essential dimensions may be obtained. The arms which support the journal yokes are cast solid with the pole-pieces, and their horizontal thickness tapers from ½ in. at the pole piece to ¼ in. where the yoke is bolted on.

In fitting the magnet frame together the best procedure is to bore the tapered holes in the lower part of each pole-piece and turn the ends of the magnet core to the same taper, but just a trifle *large*; then dress each taper down very gradually with a fine file (the core being run in a lathe) until the pole-piece can be pushed on by hand far enough to bring the end of the core within $\frac{1}{32}$ in. of the back surface of the cast iron. The pole-pieces and ends of the core should be punch-marked, so as to insure finally mounting each pole-piece on the end to which it was fitted. After dressing down the ends of the core as above described, drill and tap in each end a hole for a ¼ in. machine screw, the purpose of which will be apparent by glancing at the right hand end of the magnet in Fig. 1, where *c* is a four-armed claw or spider with a hole through the center where the arms intersect. The arms are $\frac{3}{16}$ in. thick, measured at right angles to the bolt and taper from $\frac{3}{16}$ in. to ⅜ in. thick, measured parallel with it. One of these spiders is used at each end, though the drawing shows it at only one end of the machine.

After drawing one pole-piece home solid by means of its spider and bolt, slip the other pole-piece on loosely and clamp the pole-pieces lightly between two iron plates with planed surfaces, applied between the journal arms, so as to keep the four horns of the pole-pieces in alignment; then force the second pole-piece home by means of its bolt and spider, and clamp the horns hard between the iron plates. The bottom surfaces of the cast-iron pieces should then be trued up on a planer or shaper and the clamps taken off the pole-piece horns.

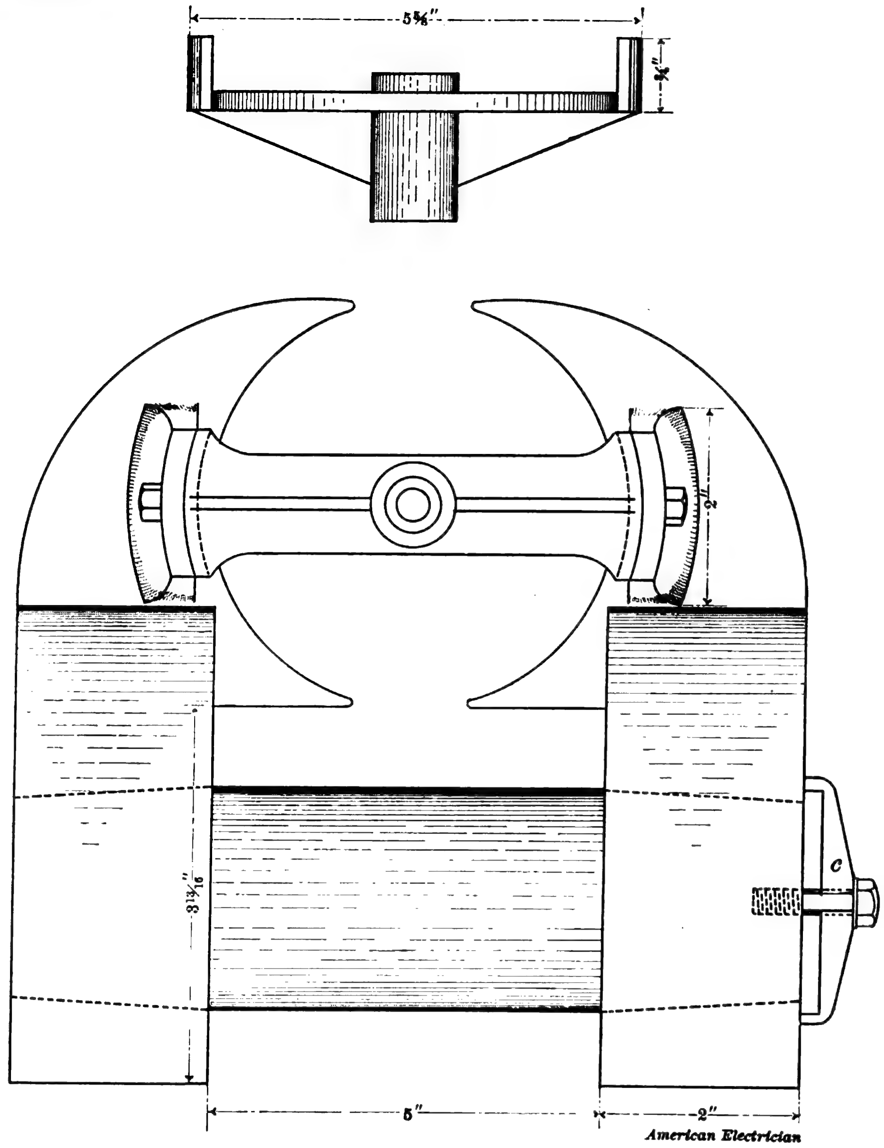


FIG. 1.—FIELD MAGNET AND JOURNAL YOKE.

The next operation is boring the armature chamber and the seats for the journal yokes. The armature chamber bore is 5 $\frac{3}{16}$ ins.; the seats for the journal yokes, marked "finished" in Fig. 3, are bored or cut to 5 ⅝ in. diameter, and this must be done before the position of the machine is disturbed after boring the armature chamber. This completes the machine work on the magnet, except the bolt holes.

The journal yoke may be made of brass or any composition metal. The bar is $\frac{3}{16}$ in. thick and 1 in. wide, except near the ends, where it flares to correspond with the width

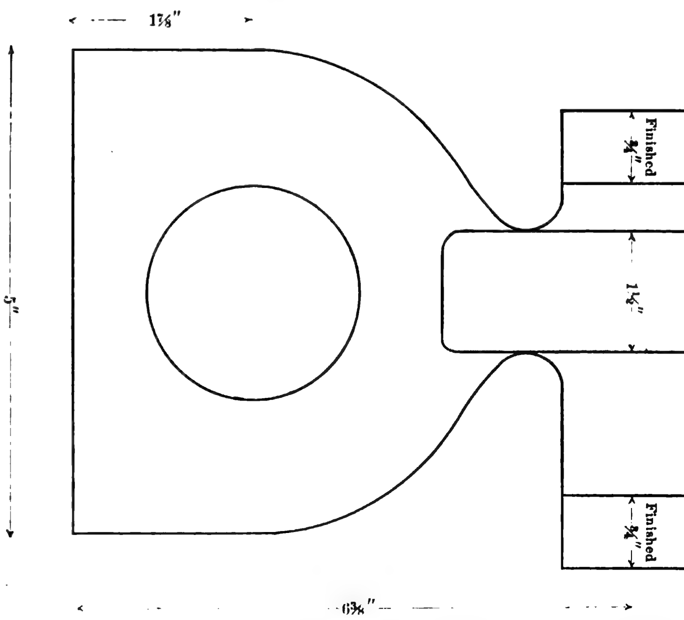


FIG. 3.—FACE VIEW OF POLE-PIECE.

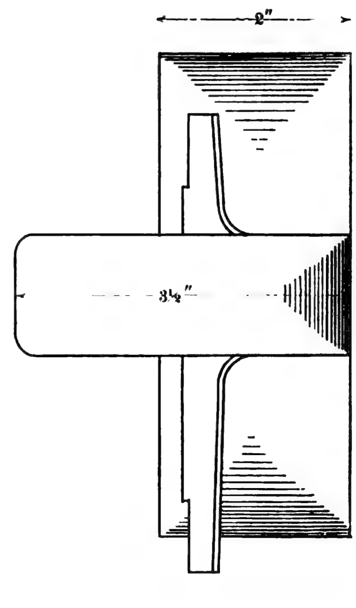


FIG. 2.—PLAN VIEW OF POLE-PIECE.

of the arms. At each end is a right-angled lug, $\frac{1}{8}$ in. thick after machining; these lugs fit the seats in the ends of the iron arms, and the yokes should be fitted to the magnet immediately after finishing the machine work on the latter, and before it is taken apart to put on the coil. The box portion is $1\frac{1}{2}$ ins. long over all, $\frac{3}{16}$ ins. of its length being on the inside of the yoke, and $1\frac{1}{8}$ in. on the outside. As shown by the plan view of the yoke in Fig. 1, there are stiffening webs starting flush near the ends of the yoke and attaining a width of $\frac{3}{4}$ in. at the box; these are $\frac{1}{8}$ in. thick. The box is $\frac{7}{8}$ in. in outer diameter and bored to $\frac{17}{32}$ in. inside; it is bushed to $\frac{3}{8}$ in. diameter. Most of the dimensions of the yoke and box may be varied to suit individual ideas, as may also the design of the box. The only essential measurements are the length of the yoke-bar the length of the box and the bore of the journal bushing. The journal yokes are held in place by $\frac{1}{4}$ in. cap-screws passing through the iron arms and tapping into the lugs of the yokes.

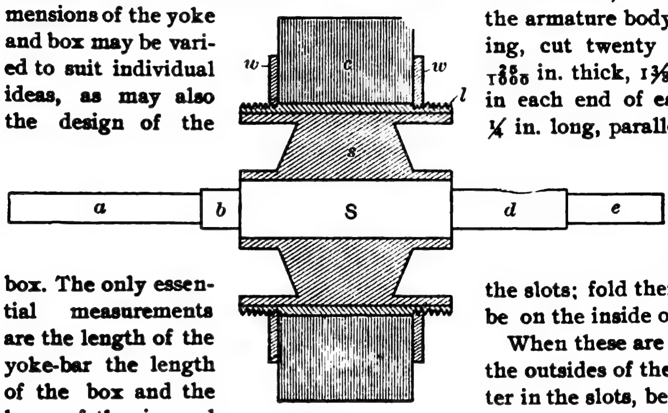


FIG. 4.

The armature core, spider and shaft are shown, partly in cross-section, by Figs. 4 and 5. The core is built up of charcoal iron (not steel) disks 5 in. outside diameter and $2\frac{5}{8}$ ins. inside, not more than $\frac{1}{32}$ in. thick; these are assembled on a brass drum $1\frac{5}{8}$ ins. long (Fig. 6), which should be $2\frac{3}{4}$ ins. outside diameter before finishing, so that it may be turned down to exactly fit the inner circle of the armature rings; the wall of the drum is $\frac{1}{8}$ in. thick after finishing, and there are four equidistant projecting lugs, *l*, $\frac{3}{8}$ in. wide and $\frac{1}{2}$ in. long, on each end, by which the drum is secured to the spider (see Figs. 4 and 5). The rings forming the core, *C* (Fig. 4), are compressed and held on the drum, *r*, by two brass washers, *w*, *w*, $\frac{3}{16}$ in. thick and $3\frac{7}{8}$ ins. outer diameter, which screw onto the lugs and ends of the drum. The core when compressed, is $1\frac{1}{2}$ in. long, and has twenty slots, $\frac{3}{16}$ in. wide and $\frac{1}{2}$ in. deep; the washers, *w*, *w*, must be set up as tight as the threads will stand.

The spider, *s* (Figs 4 and 5), is made of brass, and consists of a hub ($\frac{7}{8}$ in. in diameter, $2\frac{1}{2}$ ins. long and $\frac{5}{8}$ in. bore) and four arms having T-shaped ends, the wide part or heads of which project beyond the arms at each end, the length of these heads being $2\frac{5}{8}$ ins. and their width $\frac{3}{8}$ in. The heads of the spider arms are turned off to fit very closely inside the drum, *r*, which is mounted on the spider in such a position as to bring the spider arms in alignment with the lugs, *l*, of the drum; screws through the spider arms into the lugs hold the drum and spider together.

The shaft, *S*, is $8\frac{1}{4}$ ins. long; the portion, *a*, is $2\frac{1}{2}$ ins. long and $\frac{3}{8}$ in. in diameter; *b* is $\frac{1}{2}$ in. long and $\frac{1}{2}$ in. in diameter; the part passing through the core is $2\frac{1}{2}$ ins. long and $\frac{5}{8}$ in. in diameter; *d* is $1\frac{1}{2}$ ins. long and $\frac{1}{2}$ in. in diameter, and *e* is $1\frac{1}{4}$ ins. long and $\frac{3}{8}$ in. in diameter. The spider, *s*, should be secured to the shaft by a key, the key-seat being located at the base of one of the arms. The front end of the commutator must be located not less than $\frac{3}{16}$ in. from the shoulder where *d* and *e* join.

The armature is next prepared for winding by removing the drum and core from the spider and insulating the ends and interior of the core and the walls of the slots. Cut four rings of heavy drilling of a size to cover the washers, *w w*, and the ends of the drum, *r*; varnish two of them on one side with shellac, and applv them to the ends of the armature body. While these are hardening, cut twenty strips of micanite cloth, $\frac{25}{1000}$ in. thick, $1\frac{3}{8}$ ins. wide and 2 ins. long; in each end of each of these cut two slits, $\frac{1}{4}$ in. long, parallel with the sides and located $\frac{17}{32}$ in. from each side of the strip. Varnish these on one side, and when nearly dry, fold them into troughs to fit the slots; fold them so that the varnish will be on the inside of the trough.

When these are dry, varnish the slots and the outsides of the troughs and put the latter in the slots, bending the ends flat against the core and securing them there with a little fresh varnish. Then varnish the ends of the core (two cloth rings being on them), and one side of the two remaining rings of drilling; put these rings on top of the first ones, varnish them on the outside, and put the core in an oven to bake. The armature coils consist of No. 22 double cotton-covered wire, wound seven turns wide and thirteen layers deep. Before winding them, four strips of wood 3 ins. long, $\frac{3}{8}$ in. wide and $\frac{1}{2}$ in. thick should be screwed to the

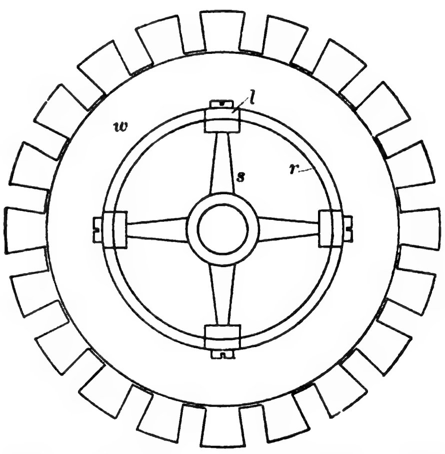


FIG. 5.—END OF ARMATURE CORE AND SPIDER.

inner wall of the brass drum, in line with the lugs, *l*, so as to preserve spaces for the four arms of the spider. A double thickness of drilling should also be applied to the interior of the drum to insulate the coils from it. The connections are the simple Gramme-ring arrangement. Before connecting up to the commutator the band wires should be put on. Use No. 19 B. W. G. soft tinned-iron wire, known by hardware dealers as "white stove-pipe wire," for the bands, and put them on under as heavy pressure as possible without endangering the armature shaft. Two bands of eight turns each, $\frac{1}{2}$ in. from each end of the core, will suffice. A strip of mica, between two strips of fuller-board, must go under each band, and the bands should be soldered at intervals, *not* all the way around. Four tin clips located equidistantly, with a dab of solder at each, will give ample security.

The commutatator (not shown) must be bored to fit the $\frac{1}{2}$ in. portion, *d*, of the shaft, and must not exceed $1\frac{1}{4}$ in. along the shaft; it must have a brush tread 1 in. wide. The lugs where the wires are attached to the segments may project toward the armature $\frac{1}{8}$ in. or so. There must be twenty segments, and a diameter of $2\frac{1}{2}$ ins. is recommended. The quadrant carrying the brush-holders

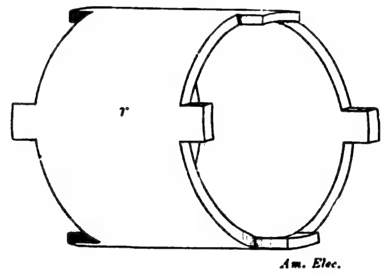


FIG. 6.—BRASS DRUM.

should be fitted to the inner end of the journal box, and carbon brushes not smaller than $\frac{1}{4}$ in. $\times$ $\frac{5}{8}$ in. (one on each side) on the contact surface should be used. If the machine be used as a dynamo (it will maintain five or six 110-volt lamps), metal brushes of the same surface should be used to reduce the resistance of the brush contact.

The field coil contains thirty-seven layers of No. 28 double-cotton-covered wire. After the magnet is fitted as described in the beginning of the article, it is taken apart and two circular magnet heads of fibre, $\frac{1}{8}$ in. thick and $3\frac{3}{4}$ ins. outer diameter, are put on with a driving fit, care being taken that the distance along the core from outside to outside of the heads corresponds with the distance between the pole-pieces (5 ins.) when the whole is assembled. A groove must be cut on the inner face of one head from the center to the outer edge, in order to lead out the starting end of the field wire, and this must be covered with two layers of oil-paper to prevent short-circuiting the successive layers of the coil. The core must be insulated with three layers of shellac muslin between the heads, and the field wire put on evenly, care being taken not to "spread" the heads; if the winding is carefully done the coil will be 216 turns in length. The number of turns in length is not a vital matter, but the depth *must* be thirty-seven layers. The ampere-turns are the same no matter what the length of the coil, but it should be as long as practicable to reduce the heat loss.

After winding the coil and securing the ends, one pole-piece is put on solid and the other one slipped on until it begins to bind, when the journal yokes must be inserted between their arms, and the bolts put in as far as possible without jamming. Then by tightening up the journal-yoke bolts and the pole-piece bolt together, being particular never to draw the yoke bolt hard against the arm, the frame will come together in its original position. As an additional precaution, it may be set on a true plane surface, and if the base of the loose pole-piece

gets out of alignment, tap the horn lightly until the frame is true on the bottom. The magnet frame must be provided with a non-magnetic base; hardwood is as good as anything, the frame being secured by flat-head brass machine screws from below, two in each casting, countersunk in the wood.

It is advisable to provide a starting switch similar to the one shown diagrammatically by Fig. 7, where *b*, *b*, are the brushes; *S*, the starting switch lever; *m*, a magnet; and *Sw*, a double-pole snap switch. The lamps shown are 50-volt, 32-CP lamps. The handle of the starting switch is provided with a spring tending to keep it in the position shown by the sketch. This starting switch is also suitable for use with the motor described in the July issue of the AMERICAN ELECTRICIAN.

The technical data for the above machine are as follows:

TERMINAL E. M. F., 110 VOLTS.

Armature current, normal	1.9 amps.
" " maximum	2.3 "
" resistance, warm	4.15 ohms.
Field current at 110 volts	.25 amp.
" resistance, warm	440 ohms.
C^2R loss in field	27½ watts.
C^2R " " armature	15 "
Hysteresis loss in armature	48 "
Magnetic flux per square inch.	
In field core	76,000 lines.
In pole-pieces	36,000 "
In air-gap	23,000 "
In armature teeth	65,000 "
In " core	85,000 "
Co-efficient of leakage	1.4
Electrical efficiency	82 per cent.
Commercial efficiency (eddy current and friction losses 10 p.c., estimated).	52 "
Revolutions per minute	2000

If it is desired to build a smooth-core machine, the armature core must be made 4½

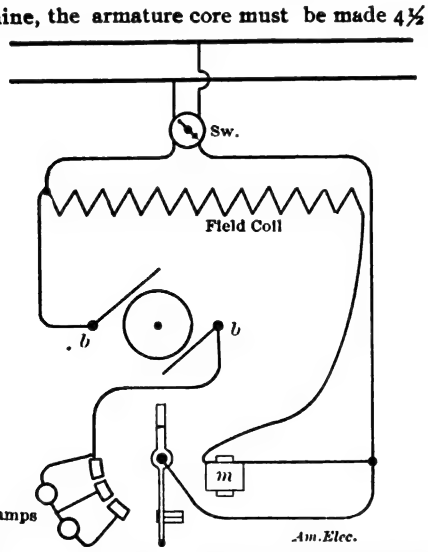


FIG. 7.—DIAGRAM OF STARTING SWITCH AND CONNECTIONS.

ins. in diameter and two grooves ⅛ in. wide and $\frac{5}{16}$ in. deep must be cut in the face of the core at opposite points for the reception of driving teeth. These are two pieces of fibre, ⅛ in. thick, ½ in. wide and 2 ins. long, set on edge in the grooves, and projecting $\frac{3}{16}$ in. above the surface of the core. The core must be thoroughly covered with two layers of micanite cloth. The number of coils is the same as before, but the coils will be twenty turns wide and five deep on the outside; on the inside of the ring the coils must lap, making ten layers of wire. The smooth core is banded just as the slotted one is, except that German silver wire must used instead of tinned iron.

WINDINGS FOR BATTERY SERVICE.

In order to adapt the two smaller motors previously described for use in connection with a battery the following windings, etc., must be substituted for those specified in the original articles:

I. One-sixth-HP motor, with drum armature, described in the February number of the AMERICAN ELECTRICIAN. The armature to be wound with *six* coils of No. 12 wire, each having twelve turns (three wide and four deep in a slot). The field wire will be No. 19, wound 17 layers deep and 83 turns in length. The commutator will have six segments and should have a brush surface ¾ in. wide; copper brushes ⅜ × ½ in. should be used, the contact faces being cut to such a bevel as to present an area ½ in. square at least.

II. One-sixth-HP motor with ring armature, described in the April number of the AMERICAN ELECTRICIAN. The armature to be wound with ten coils of No. 12 wire, each coil having 16 turns and occupying *two* (adjacent) slots. The field wire to be No. 18, wound 8 layers deep and 40 turns long in each coil; the two coils containing 640 turns in all. The commutator to have ten segments and a brush surface ¾ in. wide; copper brushes ⅜ × ½ in. to be used, the contact faces being cut to such a bevel as to present a surface at least ½ in. square each. In both cases the field winding is to be connected in shunt to the brushes instead of in series as is usually the practice in battery motor construction. These windings are for 6 volts at the terminals; the current required will depend upon the work done; each machine is capable of standing an armature current of 25 to 30 amperes.

AMERICAN TELEPHONE PRACTICE.

BY KEMPSTER B. MILLER.

SWITCH-BOARD FOR GROUNDED-LINE EXCHANGES.

The object of a telephone exchange is to afford means for placing any telephone user (subscriber) into communication with any other subscriber in the same system. The lines leading to the telephone instruments of the various subscribers radiate from a central point where they terminate in an apparatus known as a switch-board.

Switch-boards may be divided into two classes, manual and automatic. In the manual switch-board, operators—girls—are employed to make the connections called for, while in the automatic, the operation of connecting or disconnecting lines is performed by the subscriber desiring the connection. The manual switch-board only will be considered at present, as it is in almost universal use, the automatic, owing to its great and necessary complexity, having proven successful only in rare cases.

The simplest form of switch-board, one typical of the kind used in small exchanges and designed for use on grounded lines, will be considered in this article.

Each line entering the exchange terminates in what is known as a spring jack. Spring jacks are sockets containing simple switching devices and are mounted on the face of the board within easy reach of the operator. In order to make a connection with any line, plugs are provided which may be inserted into the jacks, and thus continue the electrical path from the line wire terminating therein, to and through a flexible conducting cord attached to the plug.

Fig. 1 shows a spring jack with a connecting plug inserted therein. The metallic base, *a*, of the jack, usually of brass, is drilled from its forward end to receive the shank of the plug, *P*.

A forwardly-projecting sleeve on this piece fits snugly into a hole bored in the front board, *A*, of the switch-board, to which it is firmly secured by the shoulder and small wood-screw as shown. Firmly secured to the rear end of the piece, *a*, is the line spring, *c*, formed with a rearwardly-projecting tongue, to which the line wire, *l*, is soldered. The forward end of the spring, *c*, rests normally against the pin, *p*, carried by, but insulated from, the base, *a*. A wire, *g*, leads from this pin and through the coil of the line annunciator or drop to ground. When the plug is inserted in the jack its conducting tip makes contact with the tip of the line spring and at the same time forces it out of engagement with the pin, *p*. Normally, therefore, the line wire is in conductive relation with the wire, *g*, through the medium of the spring, *c*, and the pin, *p*, from which the circuit may be traced through the coil of the line drop to ground. When the plug is inserted in the jack, however, the line is disconnected from the branch leading through the drop, but is connected through the medium of the plug to the flexible cord.

Fig. 2 shows a common form of switch-board drop. The purpose of the drop is to attract the attention of the operator whenever any subscriber wishes a connection. The coil of the electro-magnet is mounted on the back of the front plate, *c*, of the switch-board, as shown. To the armature, *a*, pivoted at its upper end, is attached a rod, *b*,

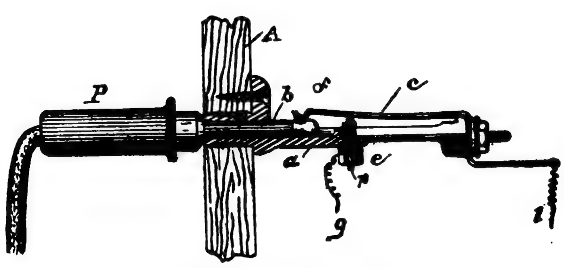


FIG. 1.—SPRING JACK.

passing forward through a hole in the front plate and provided with a hook on its forward end, adapted to engage the upper portion of a pivoted drop-shutter, *s*, and to hold it in its raised position. The attraction of the armature due to a current passing through the coil causes the hook to rise, thus releasing the shutter which falls to a horizontal position and displays to the operator the number by which that line is designated.

In order to attract the attention of the operator at night or at such times as she may not be in sight of the board, a night alarm attachment is provided on each drop, which serves to close the circuit through a battery and vibrating bell whenever the shutter is down. The small cam surface on the lower portion of the shutter, *s*, forces the light spring, *t*, into contact with the pin, *t'* when the shutter is down, thus accomplishing the above result.

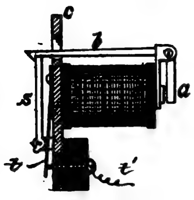


FIG. 2.—SWITCH-BOARD DROP.

Fig. 3 shows diagrammatically the circuits of such a switch-board. But two subscribers' lines with their spring jacks and drops are shown. These, it will be noted, enter by the line spring of the jack and thence when the plug is not inserted their circuits pass through the contact pin of the jack through the electro-magnets of their respective drops and to ground at *G*. In the lower portion of the figure, *R* represents the operator's receiver, *T* her transmitter, *B* the transmitter battery, *s* and *p* respectively the secondary and primary windings of the operator's induction coil, *P* and *P'* a pair of plugs, and *K*, *K'* and *K''* keys connected therewith, the purpose of which will be described later. When one of the line drops falls indicating that the subscriber on that line desires a connection, the operator takes up the plug *P'*, and inserts it into the jack bearing the corresponding number, say, No. 20. She then moves the lever of the key, *K''*, into the position shown—that is, so that the lever of this key makes contact with the stop below. This movement connects the operator's telephone set with the telephone of the subscriber calling, and circuit may be traced from ground at the subscriber's station through his instrument to his line wire, from the line wire to the line spring in the jack, thence to the plug, *P'*, cord, *c'* to the lever of the key, *K''*, through the upper contact of this lever to the lever of key *K'*, thence through the operator's receiver and the secondary of her induction coil to ground *G*.

She now ascertains from the subscriber the number of the line with which he desires connection, which we will say is No. 63. She thereupon takes up the other plug, *P*, of the pair and inserts it into jack 63. In order to call subscriber No. 63, she presses the key, *K*, into contact with its lower stop. This completes connection from the ground at the central office, through the operator's generator, through key *K*, cord *c*, plug *P*, jack No. 63 to subscriber No. 63, and through the ringer magnet of his instrument to ground. All keys being in their raised position, the two subscribers may converse with each other over the following path: Line wire No. 20 to jack No. 20, plug *P'*, cord *c'*, key *K'*, through the upper contact of this key, through the coil of the clearing-out drop to key *K*, thence through cord *c*, plug *P*, jack 63 to subscriber 63. In case at any time the operator wishes to "listen in" to ascertain if the parties are through talking, she may do so by depressing key *K''*, which throws her telephone into a branch or derived circuit of the circuit between the two subscribers. The key, *K'*, may be used to connect the generator with the line to which the plug, *P'*, is connected.

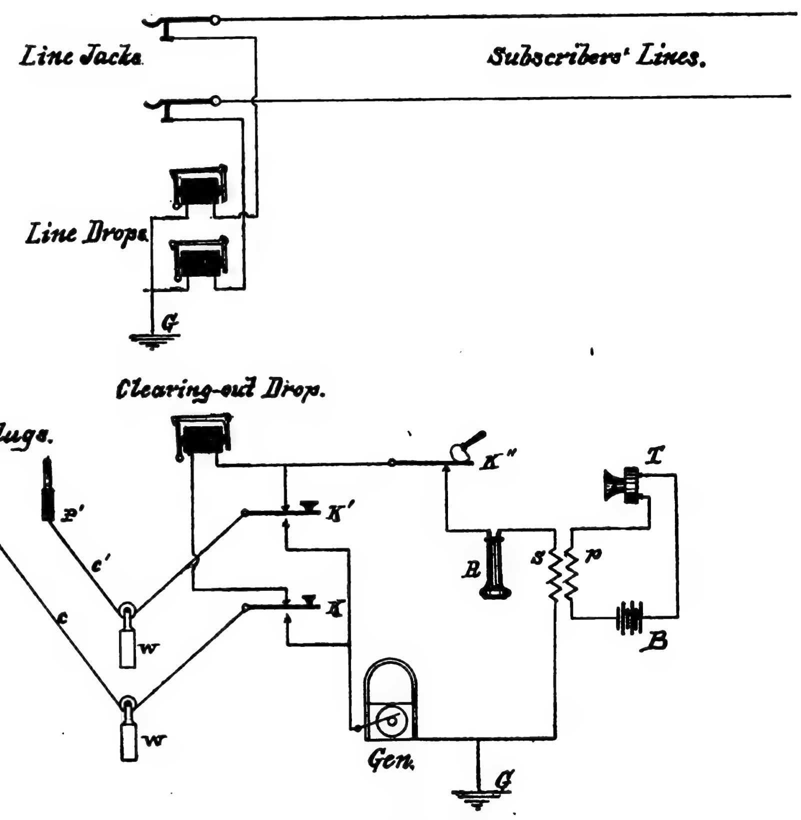


FIG. 3.—SWITCH-BOARD CIRCUITS.

The clearing-out drop is placed in the circuit between the two plugs to indicate to the operator when either of the subscribers turns his generator to ring off.

But a single pair of plugs with their corresponding keys and clearing-out drop are shown for simplicity's sake. It is usual to place ten of such pairs of plugs for each one hundred subscribers in the system, it being found that this number is sufficient to meet the requirements at the busiest periods of the day.

The drops in a board of this type are usually wound to a resistance of about 80 ohms, unless designed for multiple or bridged telephone lines, in which case the resistance of the drops is the same as that of the ringer coils of the telephone instruments on that line, usually 1000 ohms.

The details and modifications of this system will be taken up in a later article. The switch-board described must not be taken as a fair example of modern up-to-date apparatus. It was here chosen because, stripped of all complicated devices for facilitating the work of the operator, it could be more easily comprehended.

TESTING DYNAMOS.

CALIBRATED-MOTOR METHOD.

In a previous article the indicator method of testing dynamos was described. The next direct method of measuring the efficiency of a dynamo which is important is by the use of a calibrated motor. The output is measured in precisely the same way as by the indicator method, provided the dynamo is of the direct-current type and the machine is driven by a motor, the efficiency of which is known.

A calibrated motor is one in which the efficiency at all loads is accurately known and recorded in the shape of an efficiency curve such as is shown in Fig. 1. Let us suppose that a motor having this efficiency curve is driving a dynamo and requiring for this purpose 25 KW. Consulting the efficiency curve, we find that at that load the motor delivers 80 per cent. of its input or 20 KW, which is what the dynamo is receiving.

Having thus measured the output and input the efficiency calculation is an easy matter. A few matters of detail need mention. The motor is preferably direct-connected to the dynamo, for unless its efficiency curve is calculated to include belt friction, that energy will be charged up to the dynamo input, which is unfair. It is not always convenient to directly connect the shaft of a dynamo to that of a motor on account of the alignment. For this reason the arrangement shown in Figs. 2 and 3 will be of great convenience.

It consists of a flat disk, which can be securely keyed on the shaft of the motor, and provided with a slot in which a strong stud

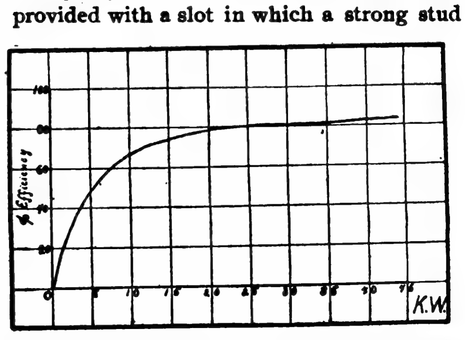


FIG. 1.—EFFICIENCY CURVE OF CALIBRATED MOTOR.

can be screwed at various radial distances. Another casting of the same shape should be provided with an assortment of split bush-

ings, so as to accommodate any size of shaft. The dynamo and motor are lined up as nearly as may be, and securely bolted down. The dynamo shaft carries one casting, and the motor its disk, with the stud before mentioned engaging in the slot in the first casting. If the motor shaft turns and the bearings are not exactly in line with those of the dynamo, the system will nevertheless revolve freely, because the pin will play radially in

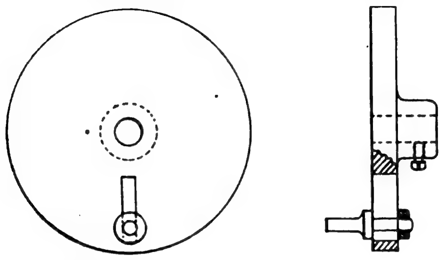


FIG. 2.—FLEXIBLE COUPLING.

its slot and thus make up for the lack of alignment. Although this will operate when the lack of alignment is considerable, yet the latter should always be mimimized because this clutch works less smoothly in proportion as the radial play becomes greater. It is hardly necessary to say that it must be accurately balanced.

For convenience in doing this, it is a good idea to provide a second slot diametrically opposite the first one in which plays a short bolt with two heavy nuts on either end. By shifting the position of this bolt it may counterbalance the driving stud with great accuracy.

In testing with the calibrated motor similar precautions must be observed as regards warming the machine up to commercial conditions as in case of the indicator method. The resistance of the armature and field magnet both change with heat, making the wire loss greater. Likewise, the hysteresis and eddy-current losses vary with the heat of the machine, and therefore it is essential that the machine be at the same temperature at which it will normally operate.

Direct measurements of input may be made by the use of transmission dynamometers, but great care must be taken to eliminate

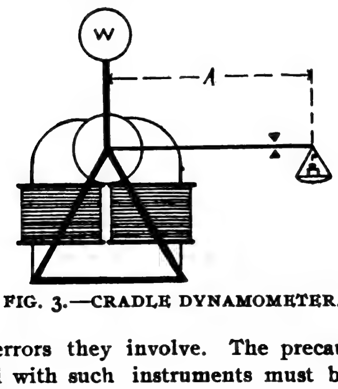


FIG. 3.—CRADLE DYNAMOMETER.

the errors they involve. The precautions usual with such instruments must be observed. There is, however, a method of obtaining the efficiency of a dynamo by means of a dynamometer which is quite accurate, but is somewhat difficult to use; it is known as the cradle dynamometer, and was devised by Prof. Brackett of Princeton College.

A platform is suspended upon knife edges so that the machine to be tested can be mounted upon it with its bearings in line with the knife edges. This is diagrammatically shown in Fig. 4. The weights, *W*, serve to counterbalance the system so that it is free to turn about the knife edges, *K*, and if abandoned to do so would remain in any position. An arm, *A*, of known length is arranged with stops to prevent the system from revolving, and on this arm are hung weights which just counterbalance the tendency to revolve when this machine is in motion. Care should be taken that the belt pulls *down* on the knife edge for otherwise the results might be vitiated. The circumference of a circle of which the weight arm is the radius, measured in feet, multiplied by the counterbalancing weights, in pounds, and by the revolutions per minute of the dynamo, and divided by 33,000, gives the horse power input.

The method is accurate to 1 or 2 per cent., but owing to the difficulty of providing the cradle which will hold a large machine, its application is not general.

The calibrated motor is of great value in measuring the losses of the dynamo, as well as in measuring the direct input, and as there is no better place in which to enumerate the various losses in the dynamo-electric machine and their methods of measuremeut, those will now be given.

The losses of the dynamo are as follows: First, friction of the bearings, air resistance, brush friction, etc., a variable factor; second, wire loss in the armature and field; third, hysteresis loss in the iron; fourth, loss in the revolving parts of the armature and in the tips of the pole-pieces by eddy currents. Were it not for the fact that the friction of various kinds, the eddy current and hysteresis losses are so irregularly variable, the efficiency of a dynamo-electric machine could be predicted with absolute accuracy beforehand, for the wire losses can be calculated by Ohm's law.

To apply the calibrated motor to the measurements of the losses of a dynamo, the motor first runs the dynamo when there is no load whatever on the latter. This gives the friction losses. The brushes are then let down and the power now necessary gives the brush losses plus brush friction. The field is then excited from a separate source to the same degree as in practice, and the power necessary includes friction of all kinds, hysteresis and eddy currents. The resistance of the armature being known, the wire losses can be calculated and, as has been pointed out in the previous article, if the losses of the machine are known, it is just as easy to calculate the efficiency as if the input were measured.

All of the losses of the ordinary dynamo increase as the load comes on. The armature wire loss is measured by the product of the resistance of the armature and the square of the current it carries. It therefore increases very rapidly with the load. The same is true of the loss in the series field coils. In good dynamos this loss is from 1 to 2 per cent. of the input of the machine. The shunt-field wire loss is usually between 2 and 3 per cent. according to the size of the dynamo. If the machine maintains a constant potential at its terminals, the loss is a constant quantity whatever the load, but if the machine is over-compounded the loss increases with the square of the voltage impressed on the terminals of the coil. The loss by eddy currents increases directly with the square of the speed, and the loss by hysteresis increases directly as the speed.

It will be remembered that these losses were measured together, as it is somewhat difficult to separate them. By taking advantage of the fact that the losses increase, as has just been stated, they can be separated, but it is a complicated process. The friction losses are a most erratic quantity. It has been customary to assume them proportional to the speed and to the load, but this is by no means accurate. They increase with the load, but it is impossible to say how. Some dynamos, which have armatures that run beneath their field magnets, lift the shaft free of the bearings as the field strengthens, thus diminishing friction. Some, on the other hand, pull on the armature so hard that the friction on the bearings is largely increased. On ship-board the gyroscopic action of the armature may do much to increase the bearing friction when the ship rolls. The quality of the oil, the kind of metal in the bear ings and its finish, and the temperature of the bearing at the time, all enter to modify the resulting loss. The losses of a dynamo other than wire l sses are sometimes classed together as a whole and called the stray power.

ELECTRIC RAILWAY OPERATION.

SINGLE EQUIPMENT.

The series-parallel controller with its two motors has practically displaced the single equipment for street railway work. There are, however, many cases where the advent of a host of summer cars compels the street railway manager to practice the economy of single equipments and split up his double ones; and there are also cases where a single equipment is much superior to a double one—namely, those of interurban service. This statement is likely to be criticized and the next several paragraphs will therefore be devoted to a few words in its defense.

On long interurban lines where but few stops are made, there is practically but one speed and a single running notch suffices, although, as is well known, single equipments have been made with two and sometimes three running notches. It is pretty generally admitted that one large dynamo operates at a higher economy than two smaller ones, equal in combined capacity, and this is true whether the machine is a motor or dynamo. It therefore follows that a single equipment will take less current than a double equipment of the same capacity for this reason alone.

But this is not all, for it is very rare that the motors of a double equipment act together; one is almost certain to take more current than the other, and it is easily possible for one motor to be heavily overloaded and the other lightly loaded. And aside from these poor efficiency conditions, the power wasted in skidding of the wheels greatly detracts from the output of the double equipment in miles per kilowatt-hour and gives the single equipment another point of vantage.

An apt illustration of how a single equipment can do more work in proportion than

a double one often obtains in the case of hill climbing. As the grade increases and the load becomes very heavy, the disadvantages of the double equipment already referred to will become accentuated and be apparent in its performance, and a single equipment proportionately loaded will often run away from the double one.

Having thus demonstrated that the single equipment is by no means a dead letter, it may be appropriate to describe some of the methods of connection and control which

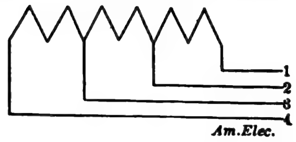


FIG. 1.—RHEOSTAT CONNECTIONS.

are commonly used, for the foregoing has been rather a digression from the type of article that this was intended to be. The chief objection to a single equipment is the uneconomical variation of speed, and with the most usual conditions under which a street railway works it is an insurmountable one. The control is simply a rheostat in series with the motor, and unless the rheostat is heavily built with thick wire, this provides but one running notch, for the reason that if the rheostat is not immediately cut out it will overheat.

A second running notch can be provided by the device of feeding the current into the motor at some place in the field circuit, as shown in Fig. 1. Usually, this place cuts out about half of the field bobbin, thus weakening the field and increasing the speed of the motor. A number of these

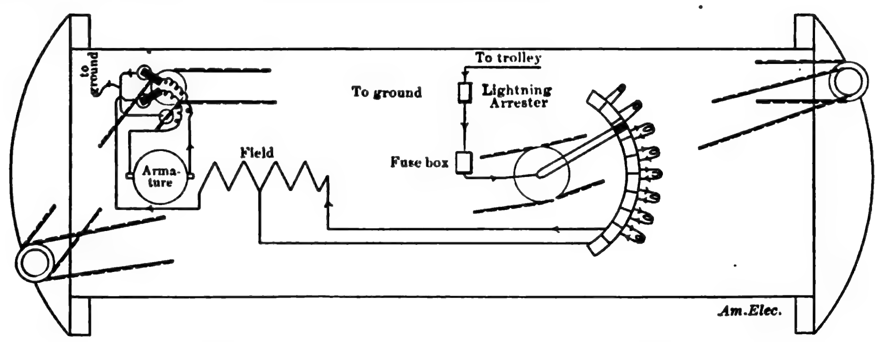


FIG. 2.—CONNECTIONS FOR SINGLE EQUIPMENT.

auxiliary field terminals may be provided, but if too much of the field bobbin is cut out by this method, the motor will operate with considerable sparking at the commutator. Another reason why the loop method increases the speed of the motor is that the drop of voltage in the field magnet is much reduced when the loop is cut in, and the potential at the armature terminals is, therefore, greater.

The usual methods of connecting a single equipment is to utilize a portion of the contacts on the series-parallel controller. The electrical connections are substantially the same as if one of the motors were cut out by its appropriate switch and its connections to the controller fingers omitted. In the General Electric controllers the throwing of this cut-out switch interlocks with the controller arm and limits its sweep to one-half the number of notches. In controllers which do not have some such protective device it is best to block the handle, for even though the operator is conscious that he must move the handle no further than a certain point, he is liable to accidentally do so, thus breaking circuit and causing a bad arc in the controller or grounding the trolley wire, according to the type of controller. Either of these accidents is to be avoided. It is rather poor economy to use a series-parallel controller for this purpose, for the reason that the same thing can be accomplished with a much less expensive device.

Fig. 2 shows the T-H. method of controlling a single equipment and the connections thereof, and it is a very satisfactory arrangement in spite of the fact that there are moving parts under the car. The rheostat and reversing lever are operated by a chain and sprocket; the chains of these two members pass around two sprocket wheels on the ends of the controller spindles, one of which is a tube and surrounds the other. The motion of the reversing lever is limited by stops as shown, but the controlling handle can make two revolutions before the limit of its travel is reached. The resistance consists of iron stampings packed between mica plates and arranged to form a quadrant of a circle over which a contact-arm travels. It is a very rugged and substantial affair. The last two contacts are the running notches. As the arm proceeds over the sector, portions of the resistance are cut-out, as diagrammatically shown, and when the contact No. 1 is reached, all of the resistance is cut-out. When the contact No. 2 comes under the lever the current enters through a special lead, cutting out about half of the field coil, and the motor is then said to be running on the loop.

An examination of the reversing switch shows that it reverses the armature terminals relatively to those of the field. Both the reversing switch and the controlling rheostat are provided with two sprocket wheels sending a chain to each end of the car, as shown; therefore the controller spindle in the rear turns in unison with the one in front, which has doubtless been noticed by the reader if he has ever ridden on such a car.

The old Sprague method of controlling a motor by the commutated-field device—that is, a subdivision of the field coils into sections and the excitation of these sections by connecting them in series or multiple with one another—provides a great many more running notches, but the difference in speed between these notches is not so marked as to make it worth while to employ the method except in special cases.

The motorman who is running a single equipment should learn the art of drifting, which is by no means as easy as it appears on paper. In crowded sections where a reduced speed has to be maintained, this is accomplished when rheostatic control is used by turning the power full on for an interval, and as soon as the car has gained headway cutting it off altogether and allowing the car to drift along. Thus the controller will always be on a running notch, but unless judgment is used, the motion thus produced will be very disagreeable to the passengers, and therefore some experience is necessary.

The invariable rule is to drift the car as much as possible and use the brakes as little as possible, as stated by Prof. Herman F. Hering in a recent article. Thus, the motorman in making a stop should carefully judge the distance and bring the car to a standstill by shutting off the power at the proper point and avoiding the use of the brake. Similarly, in descending hills no power whatever should be used. In cases where the run has to be made in quick time, it may be that these rules of economical running will have to be transgressed to a certain extent, but they should always be observed as much as the conditions will permit.

CENTRIFUGAL AND INERTIA GOVERNORS.

BY JAMES F. HOBART, M.E.

In a previous article in these columns (April, 1897) the fundamental principles of the action of centrifugal and inertia fly-wheel governors were explained. In another article which appeared in the March issue, the effect was shown on steam distribution, first, of changing the angle alone between the eccentric and crank, and second, the effect of changing the throw of the eccentric alone.

It was shown that if an eccentric is advanced the events of the stroke are affected as follows: (1) the lead is earlier; (2) steam is cut off earlier in the stroke, thereby causing greater expansion; (3) the release is earlier, and (4) compression begins earlier. It was also shown that if the throw is decreased, (1) the lead is later; (2) the cut-off is earlier; (3) the release is later, and (4) compression begins earlier.

It is therefore evident that if the throw and eccentric angle are simultaneously varied, the leads may be retained approximately constant while the expansion is

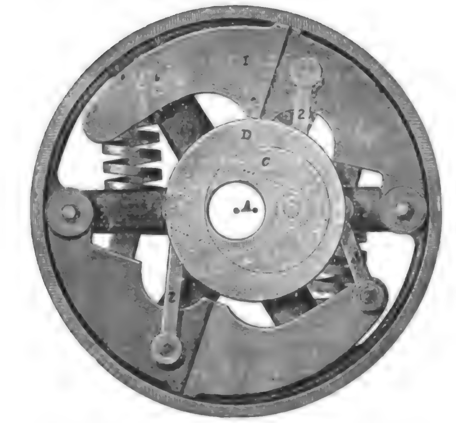


FIG. 1.—ARMINGTON & SIMS ENGINE GOVERNOR.

varied, the compression, however, not being thereby greatly influenced.

The action of centrifugal and inertia forces in governors is so thoroughly set forth in the

April article that it need not be discussed here, and undivided attention will therefore be given in this article to noting the manner in which the above principles are practically carried out in fly-wheel governors with reference to actual automatic engine governors.

Of automatic engine governors there are two principal forms—one in which the throw and eccentricity are simultaneously varied by means of one eccentric moving on another; and another type in which the eccentric is pivoted and swung back and forth across the shaft, its movement being regulated by means of springs and weights.

The first type is illustrated in Fig. 1,

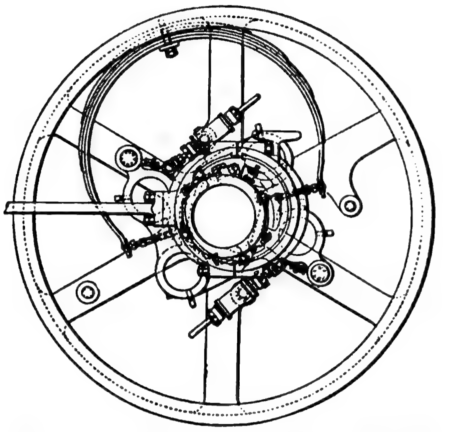


FIG. 2.—McINTOSH & SEYMOUR GOVERNOR DOUBLE VALVE, AT REST.

which shows an Armington & Sims governor. In this governor the lower weight moves the eccentric, *D*, upon the eccentric, *C*, which serves to change the stroke by varying the distance between the centers at *A*, thus making the stroke longer or shorter. But both weights also act on the inner eccentric, *C*, which serves to move that eccentric ahead or back, thereby changing, of course, the angle of eccentricity. It is ob-

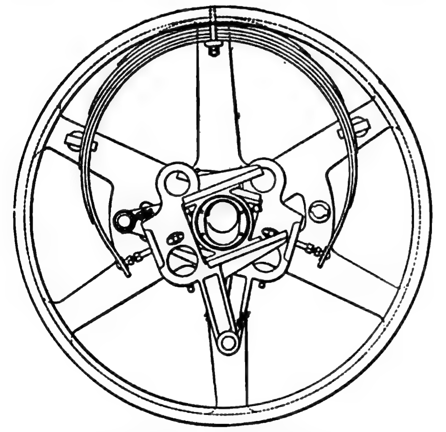


FIG. 4.—McINTOSH & SEYMOUR GOVERNOR SINGLE VALVE, AT REST.

vious that the movement of eccentrics have to be considerable in order to give the desired range of travel. In fact, the distance *A*, when the engine is starting, must be nearly or quite double what it is when cutting off at speed, running light. In this governor centrifugal force is almost exclusively employed.

The McIntosh & Seymour engine governor, illustrated by Fig. 2, at rest, and in Fig. 3 when up to speed, is a good example of the method of governing by revolving the eccentric upon the shaft. The springs are made of plate, after the manner of carriage springs. The sensitiveness of the governor is adjusted by the connecting pins between the springs and weights, which are arranged to telescope for that purpose.

The speed of the engine is adjusted by adding to the weight of the centrifugal weights or levers, through the medium of lead disks placed in the holes seen in the weights; set-screws are provided for holding the disks, which are made of various weights to suit.

It is claimed that this governor can be adjusted to give "practically perfect regulation, without any tendency whatever to race under a widely fluctuating load;" it should

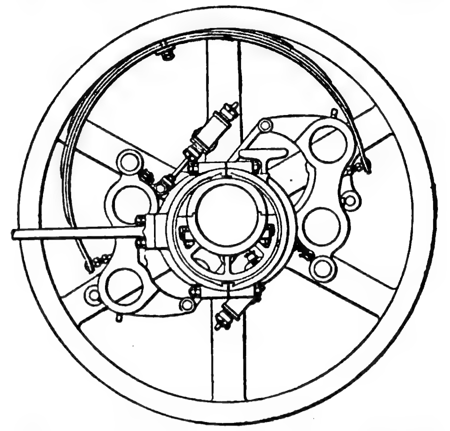


FIG. 3.—McINTOSH & SEYMOUR GOVERNOR DOUBLE VALVE, RUNNING.

be borne in mind, however, that this governor is designed for a cut-off valve only, the main valves being driven by fixed eccentrics. This allows any one of the four operations of cut-off, admission, release and compression, to be varied independently of the others. In this engine, it may be remarked, the cut-off valve travels in an opposite direction to that of the main valve, thus making the closure very quick and sharp.

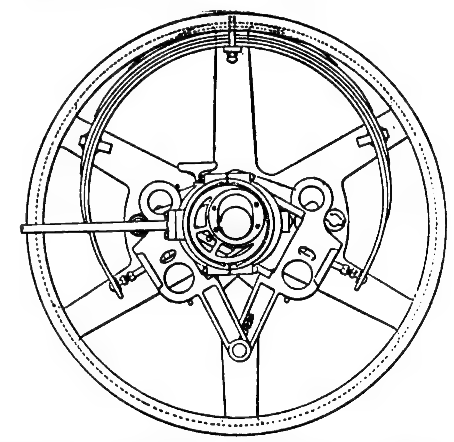


FIG. 5.—McINTOSH & SEYMOUR GOVERNOR SINGLE VALVE, RUNNING.

In arranging a governor for the single-valve engine of this make, the form shown above was changed somewhat, as illustrated by Figs. 4 and 5. Here we have the application of a pair of levers and weights, operated by centrifugal force, and controlled by springs, much in the some manner as in the case of the double-valve engine, but with the difference that for the single-valve, both weights are pivoted to the same point.

The eccentric is bolted to a sort of double cross-head, which works in jaws in the weights. The eccentric is further held in place by a sort of pendulum lever which is pivoted to the fly-wheel, as shown in Fig. 4. The governor is shown in action by Fig. 5, and it will be noted that the action is almost wholly to change the length of stroke, by


FIG. 6.—IDEAL ENGINE GOVERNOR.

moving the eccentric to or from the center of rotation of the shaft.

It will be noted that the springs are attached approximately at right angles to the weighted levers. This means that the springs must undergo a great deal of motion, and must be very long in order to do this and not be stiff or weak at various degrees of extension.

In the form of governor used on the Ideal engine, which is shown by Figs. 6 and 7, a heavier spring than the above is used, requiring less movement. Here the springs are attached at an adjustable angle with the weight lever, and the pendulum—so common in wheel governors—is fully in evidence.

To change the speed of this engine, move the weights. To make the governor more sensitive, move the spring attachments. By having the springs more in line with the levers, a heavy spring and light movement thereof is required, something easier to attain than a long, even movement of a more flexible spring. The increase of strength under tension is compensated for in this governor by the spring and lever coming more in line or parallel, as they move outward.

In Fig. 7, this governor is shown improved and much simplified, only one spring, weight and lever being used, and it will be


FIG. 7.—IDEAL ENGINE GOVERNOR, IMPROVED.

noted that the length of the "pendulum" is much shortened. There is a purpose in this, which will appear later, when it is demonstrated that the shorter the pendulum, the greater will be the angular advance of the eccentric.

Fig. 8 illustrates the Rites inertia governor, used on the "Imperial" automatic engines of the Weston Engine Company. The governor consists of but a single moving

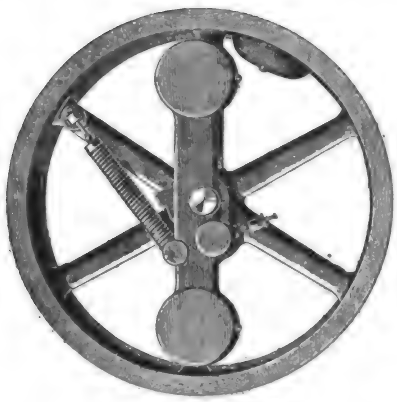


FIG. 8.—IMPERIAL ENGINE GOVERNOR.

piece swinging on a single supporting pin, the eccentric even being integrally formed with the weight structure. In this type of governor, the centrifugal and inertia elements are combined in the same structure, the latter being relatively so great that extreme changes of load are provided for coincident with such variations, without waiting for the otherwise necessary manifestation of centrifugal force.

The principal feature of the governor is the manner in which the inertia element obviates the disturbing action of gravity, thus enabling balancing weights to be dispensed with and the whole governor reduced to a single piece.

Figs. 9 and 10 show the old types of Ball,* and Ball & Wood governors, respectively. Though no longer made, they will be referred to, as they are on many hundreds of engines now in use. The "pendulum" is not used in this form of governor, an appliance termed the "suspension-eccentric" being used. This furnishes some points not found in other governors to the same degree, namely, the combination of change of lead and stroke of valve.

To obtain this result, the eccentric, which carries the valve rod wrist-pin, is made fast, not to the pulley direct, but to a disk placed eccentric with the center of fly-wheel. In other words, the rod wrist-pin is attached to

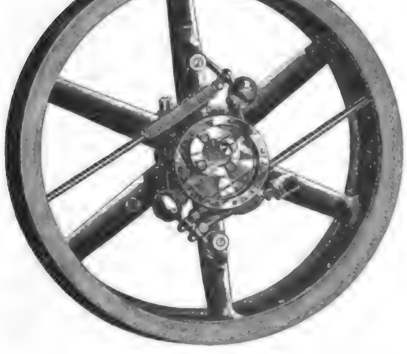


FIG. 9.—BALL ENGINE GOVERNOR.

a plate which is bolted to an eccentric strap. This strap is carried eccentric to the fly-wheel.

Fig. 11 shows the connection, the eccentric, *a*, being bolted to the fly-wheel, but *not* concentric to the wheel. The strap, *b*, *b*, is made in halves, in the usual manner, and the plate, *c*, is bolted thereto. To the plate, the pin, *e*, which drives the valve is attached. The springs are not shown in Fig. 12, only the supplemeniary spring, through which the weights are connected with a dash-pot. This allows of a very sensitive connection herewith.

To change the speed of this engine, it is only necessary to loosen the clips, and slide the springs to or from the weights, as seen in Figs. 10 and 11. No movement of weights

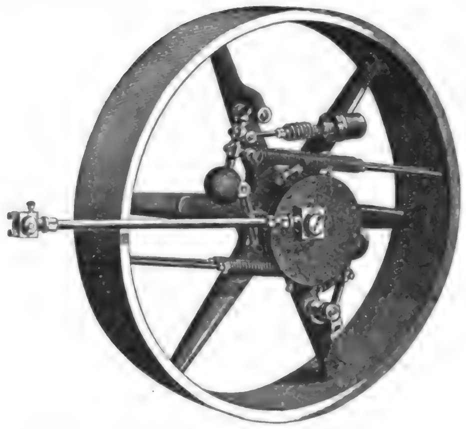


FIG. 10.—BALL & WOOD ENGINE GOVERNOR.

is necessary, and there is no adjustment of springs, except, as in all engines, to tighten up the springs a little when they become too slack to perform their office.

But there is one characteristic which is not found in other governors noted here, and that is, the action of the eccentric, which makes the valve change both lap and lead to a considerable degree—much more, in fact, than governors with the pendulum

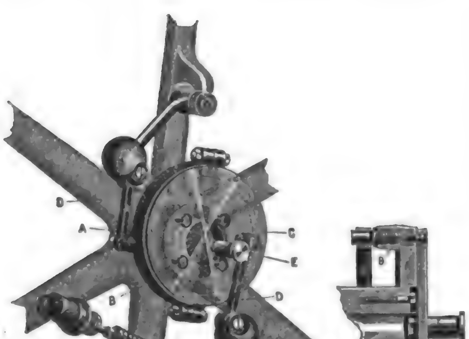


FIG. 11.—DETAILS OF BALL & WOOD GOVERNOR.

connection, unless the pendulum connection is marvelously short.

This matter is set forth by the diagram marked Fig. 12. In this figure, *b* represents the center of shaft and wheel. The center of wrist-pin is at *a*, and the center of the eccentric is located at *d*. In a certain position of the governor, the circle of which *b* is the center, is the travel of the valve, and stands in the line, *e d*, a certain number of degrees ahead of the crank.

When the governor acts, the eccentric is rotated about *d*, as a center, and the pin travels from *a* to *c*. As the whole revolves about the common center, *b*, it is readily seen that not only is the travel of valve increased from the diameter of circle *b*, to that of circle *e*, but the angularity of the eccentric has increased the amount *a*, *c*.

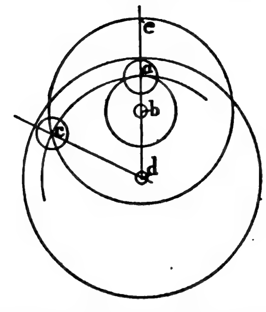


FIG. 12.—THE SUSPENSION ECCENTRIC.

This action, to a certain extent, also takes place with the "pendulum" apparatus, and it is the more marked the shorter the length of the pendulum. Indeed, in the suspension eccentric, there is what amounts to a very short pendulum arrangement, the length being that from *b* to *d*, or shorter than any form of regular pendulum can be arranged.

The present Ball & Wood governor, shown in Fig. 13, is of the inertia type with a swinging eccentric. The eccentric center moves across the end of the shaft from an outside point, thus giving a lead which varies with the point of cut-off from a maximum at the latest point, to zero, the governor weights in the latter case occupying their extreme outward position. As will be seen from the position of the weight pivot, the inertia of the weights and centrifugal force both come into play upon variation of speed. The total motion of the weights is small, which increases the sensitiveness of the governor.

Any alteration of speed is obtained by changing the amount of the weight in the pockets of the lever arm. To make the governor more powerful to overcome any disturbing influence, the weights are increased, and also the initial tension of the spring by screwing up the yoke-bolt located near its face. When it is desired to have the governor between the wheel and the engine, a slotted eccentric takes the place of the crank-pin shown in the illustration.

I will describe but one other type of governor—the McEwen, which is sometimes called the "inertia governor," but which really uses both the forces of inertia and of centrifugal motion. Figs. 14 and 15 show

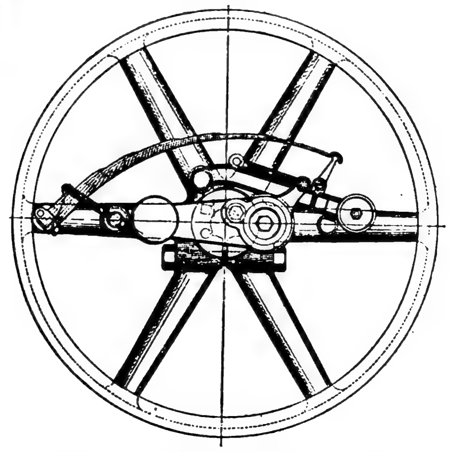


FIG. 13.—NEW BALL GOVERNOR.

* For description of the new Ball governor, see page 374.

this governor, and the inside and outside of of the wheel respectively. As seen from the inside (Fig. 14) of the wheel, the device resembles a simple centrifugal governor,

FIG. 14.—McEWEN GOVERNOR, INSIDE OF WHEEL.

with weight, spring and dash-pot, and this is what it really is.

But on the outside of the wheel (Fig. 15) is found an inertia governor, which is really nothing but an exaggerated "pendulum," the ends being elongated and fitted with

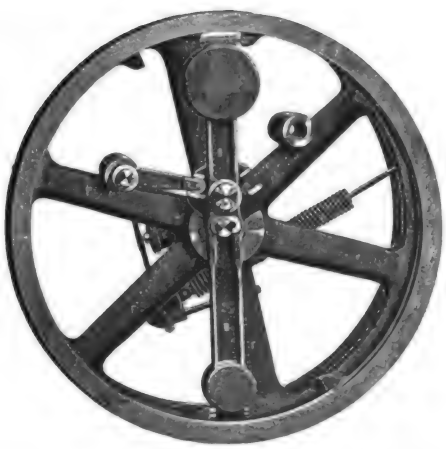


FIG. 15.—McEWEN GOVERNOR, OUTSIDE OF WHEEL.

weights, the mass of which is acted upon by inertia whenever the engine increases or diminishes its speed.

Recently this governor has been greatly improved, many of the parts being dispensed with, and the inertia weights so

FIG. 16.—IMPROVED McEWEN GOVERNOR.

placed as to become centrifugal weights also. This arrangement is shown by Fig. 16, as applied to the McEwen engine at present. This is one of the most simple forms of governor which combines the two forces. It has only one spring, one dash-pot, and one weight, if we may except the small counter-weight, *e*, which is attached opposite to, and counterbalances, the dashpot so that it may have no centrifugal action.

INTERIOR WIRING.

IRON-ARMORED CONDUIT.

An iron-armored conduit installation is practically a job of plumbing, and a gang of plumbers under the direction of an electrician familiar with the manipulation of the conduit would have no difficulty in doing a thoroughly satisfactory job. The conduit is cut with a pipe-cutter in the same way as gas-pipe,* but care should be taken not to split the inner lining. The best way is to cut the conduit nearly through with a pipe-cutter and finish the job with a hack-saw. The ends should then be reamed off square with reamers, such as are shown in Fig. 1. These reamers may be used in a bit-stock, and are provided with plug mandrels which fit them to any size of conduit.

The joints made between two lengths of conduit differ somewhat from a gas-pipe joint; the coupling has straight instead of tapering threads, and a fibre washer is slipped in between the two pipes as the coupling is screwed up and is compressed between them, and serves to render the insulation through the joint more continuous. The two tubes are supposed to be drawn together by the coupling until the ends are tightly pressed together. Care must be taken that no splintering projections in the interior insulation be allowed, for they will be forced into the tubing or will buckle the insulation beyond. The joint will act much better in repelling moisture if it is red-leaded.

The piping may be secured to the walls by staples, straps or in any way that gas-piping is secured, as it is practically non-crushable by any ordinary handling. Bends may be made in the tubing of a long, sweeping nature, provided the section of the tube is no contracted by such bending. All bent tube, including the regular elbows and fittings, must be investigated with a steel fishing-wire in order to determine whether there are any obstructions existing therein before being installed. It is very difficult to bend iron-armored tubing even with the most improved appliances without splintering or buckling the interior insulation to such an extent that it forms a serious impediment to the drawing in of the wire.

The iron-armored conduit system is provided with cast-iron junction boxes, double elbows, outlet elbows and fittings corresponding to those of the brass-armored system described in a previous article, and of which Figs. 2, 3 and 4 are typical.

Iron-armoured tubing is now considered to be the best possible installation of interior wiring, and is almost universally specified for fire-proof buildings. Where a combination of brass and iron-armored conduit is used the joint shown in Fig. 5 is useful.

Almost all conduit systems are run on what is called the double-tube system; that is each tube contains but a single wire, thus making two tubes per circuit. The underwriters' rules in most cases require this. In the case of iron-armored conduit, exception has been made and the use of two wires or of a twin conductor in a single tube is allowed. With alternating current installations in iron-armored circuit it is absolutely necessary to have the two wires in one tube, for otherwise the inductive drop would be so great as to be prohibitive.

Although the cost of iron-armored tubing is considerably in advance and almost double that of any other tubing, the total cost of an installation on this system is but little greater. The single-tube system being per-

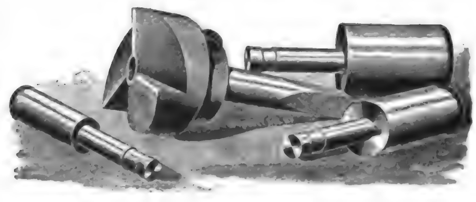


FIG. 1.—REAMERS FOR IRON-ARMORED CIRCUIT.

missible, only half as much conduit is necessary, and considerably less labor, with the result that the difference of cost of material is practically wiped out.

An installation of interior conduit is supposed to provide a raceway for the wire into which it may be drawn or withdrawn at pleasure. Therefore, in putting up the conduit it is customary to specify that no wire shall be drawn until after the plaster has been put on, or that strings or other drawing appliances shall not be inserted while the conduit is in process of installation for the purpose of subsequently drawing in the wire. This compels the contractor to test every run of conduit he puts up beforehand to be sure it will draw without trouble, which is what he should do whether he is bound by such a clause in the specifications or not.

FIG. 2.—OUTLET BOX.

In drawing in wire the first thing to do is to push through the tubing a long snake of hoop-skirt fishing wire. After the end has appeared, it should be bent into a hook and double English twine drawn into the tube. The end of the wire should be hooked over and fastened to the twine and drawn in, and

FIG. 3.—COVERS FOR OUTLET BOXES.

by judicious pulling of the string at one end and pushing of the wire at the other it should be easily and rapidly drawn into place. Powdered soapstone blown into the tube

before drawing wire will facilitate matters.

All wires larger than No. 8 Brown and Sharp gauge should be stranded, for otherwise it would be difficult if not impossible to draw them through the conduit. Where heavy feeders or cables are to be installed, where it is impossible to draw them through a tube owing to turns or extreme non-flexibility, it is better not to attempt to use a conduit at all unless it be of the iron-armored type. A brass-armored or flexible conduit would be torn to pieces by the drawing of the wire, and if it were put on length by length before the conduit was confined to its place by the enclosure of the walls, it would be analagous to a case of protecting a powerful suspension-bridge cable with a paper wrapping. The iron-armored conduit, however, will prevent nails from entering the cable, and even though the cable and conduit are installed together and it is impossible to remove the former from the latter, it will be a decided advantage. In similar cases where the conduit runs in an elevator shaft, iron-armored conduit will be quite effective in preventing abrasion or chafing, but brass or flexible conduit will be comparatively inefficient.

FIG. 4.—JUNCTION BOX AND COVER.

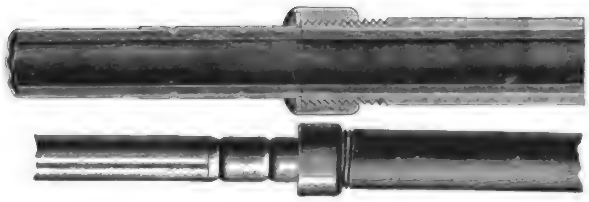


FIG. 5.—CONDUIT JOINT.

In an interior-wiring installation of any kind it is an excellent idea to test every circuit for grounds before connecting it on to its feeders. If the test is reserved till the installation is complete, grounds will be found which will be difficult to locate. A prolific source of grounds is in the fixtures which are subsequently installed, and this has often caused an excellent job of wiring to fall into disrepute. The fixtures are usually sold under separate contract and installed by men who know little or nothing about electrical matters other than that the two outlet wires should be connected to the two fixture wires. Even though he may do this job in a satisfactory manner and thoroughly solder and tape his joints, which is highly improbable, the wiring of the fixture itself is liable to contain an open circuit, short circuit or ground, and trouble arising from these causes is always charged up to the wiring contractor. It is usually better policy for him to insist on wiring and installing the fixtures even if he has to do it at small profit rather than allow the parties supplying them to do so.

Wobbling the Earth's Charge.

Under startling "scare heads" the New York press recently contained an alleged interview with Nikola Tesla, in which the latter was made to assert that he had succeeded in violently disturbing the electrical equilibrium of the earth by means of Teslaic waves propagated from the Tesla laboratory.

LESSONS IN PRACTICAL ELECTRICITY

INDUCTANCE AND CAPACITY.

In the August number an incorrect statement appears, in which difference of potential to which a point in an alternating current circuit is subjected, is confounded with the voltage of that circuit as measured by an instrument. Referring to Fig. 3, any point in a wire in which the E. M. F. varies according to the curve shown, is subjected during a cycle to a total change of potential whose value is represented by the distance between the peak of the positive alternation and the peak of the negative alternation. In a circuit having a mean effective voltage of 1000, the maximum positive or negative value is 1414 volts, and the total change of potential during a cycle is twice this, or 2828 volts, this being the total change of potential to which any *point* in the circuit is subjected during a cycle or complete period.

This total change of potential, however, cannot be registered by an instrument. In an alternator a wire is "dead" electrically when in such a position that no E. M. F. is generated in it, and the voltage which an instrument measures is alternately the positive and negative potential from this point. We may consider that one ring of an alternator always remains at zero potential, the potential of the other ring varying as the conductor between the two cuts through the lines of the field, alternately rising to a positive maximum and falling to a negative maximum and never being subjected to a potential higher or lower than the value of either of these maxima, though during a period it is subjected to a change of potential equal to their sum. The reason is, of course, that the two rings are never simultaneously at the maximum positive and the maximum negative potentials, the greatest range being from zero to one or the other of these points.

In a previous lesson the effect of an inductance in an alternating-current circuit was considered, and in the present one the effect of capacity in such a circuit will be taken up.

As is well known, if a condenser is placed in an electrical circuit, as the potential of that circuit is raised the charge of the condenser is increased, and decreased if the potential is lowered, the quantity of the charge being the product of the capacity of the condenser by the voltage between its two sides.

In a plate condenser, such as that shown in Fig. 1, the capacity depends upon the area of one of the two plates, upon their distance apart and upon the specific inductive capacity of the dielectric separating them. If sheets of tin-foil 1 ft. square are separated $\frac{1}{100}$ in. by paraffined paper, the specific inductive capacity of which is twice that of air, 39 sheets will be necessary to form a condenser of one microfarad capacity; if the foil sheets were merely separated by air, twice this number would be necessary. In the case of a concentric cable, one side of the condenser is the inner conductor and the other side the outer conductor, the dielectric being the insulating material separating the two conductors.

In the case of an alternating-current circuit, as the potential rises electricity flows into a condenser in circuit, and as the current falls the condenser discharges back into the circuit. We may consider that the two sides of a condenser always seek to remain in balance. When the voltage of the circuit in which the condenser is placed rises, this balance is destroyed and current flows in to re-establish it. When the voltage falls, current flows in opposite direction out of the condenser until the balance is again re-established.

The action of inductance is opposite to that of capacity, and may be illustrated by an analogy having reference to the exhaust of a steam engine. If a throttling valve in the exhaust pipe of a steam engine is partly closed, the exhaust will, of course, be choked; if now the exhaust pipe is given an opening into a condenser, the effect of this choking will be overcome by the draft of the steam condenser and the exhaust thus be made to act as it did before the pipe was throttled. An inductance produces in an electrical circuit in which the current is increasing, an effect similar to that of the throttling valve, while a capacity has an action similar to that of the condenser. When the current decreases in value the analogy still holds if the action of inductance is compared to that of a condenser and a capacity with that of a throttling valve. This method of viewing the comparative actions of inductance and capacity is often useful in seizing the significance of these phenomena in alternating-current circuits.

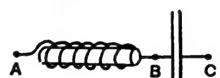


FIG. 1.—INDUCTANCE AND CAPACITY IN SERIES.

In one system of polyphased working the inductance of the motor is neutralized by means of a capacity, the result being that the alternating current flowing through the motor follows the simple form of Ohm's law that applies to direct current; that is, the action of inductance is neutralized by the opposite action of the capacity, as partly illustrated in the exhaust-pipe analogy.

Concentric cables may form a condenser of large capacity for the reason that the two sides of the condenser—the inner and outer conductor—are close together. On the Ferranti underground system in London it was found that the capacity not only neutralized the inductance of the circuit, but overbalanced it, with the result that the voltage, instead of dropping toward the end of the main, would actually rise, thus giving a higher voltage there than at the generator.

This resulted, not from a capacity in itself increasing the voltage, but from the fact that the resultant of an inductance and capacity may do so, as will be shown later.

Suppose in Fig. 1, *A B* represents an inductance, and *B C*, a capacity, the two being in series in an alternating-current circuit. We will also further suppose that the inductance, *A B*, and the capacity, *B C*, have such values that, referring to the exhaust analogy, the choking action of the former will be neutralized by the "drafting" action of the latter. Referring now to Fig. 2, suppose *D* is the current which the inductance, acting as a generator of E. M. F., tends to set up when an alternating cur-

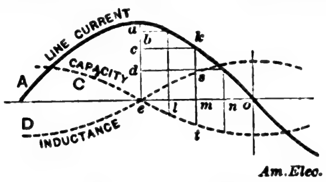


FIG. 2.—CURVES OF INDUCTANCE AND CAPACITY.

rent of the value, *A*, is sent through it. Then *C* will represent the current which the capacity will tend to set up under the same circumstances. As the current, *A*, falls from *a* to *c*, a number of lines of force, corresponding to the amount of this change of current, will cut through the coils forming the inductance, thus generating in it an E. M. F., which in turn will tend to send a current of a value *s m*, in the same direction as the current, *A*, an inductance always tending to prevent the rise or fall of the current flowing in the circuit in which it is placed.

On the other hand, as the voltage falls, the capacity will tend to discharge into the circuit a current of the value of *m t*, the direction of this current, however, being opposite to that of the actual current flowing in the circuit. It will thus be seen that the current which the inductance tends to add to the impressed current flowing in the circuit will be neutralized by the current opposite in direction, which the capacity tends to throw into the circuit, and consequently the main current will rise and fall in precisely the same manner as if neither the inductance nor capacity were absent. That is to say, the value of the main current will in that case

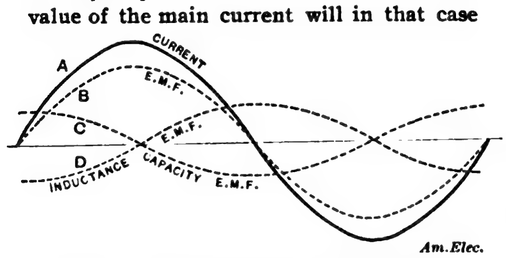


FIG. 3.—CURVES OF INDUCTANCE AND CAPACITY.

depend only upon the voltage and resistance of the circuit, as in the case of a direct current, and the current flowing, *A* (Fig. 3), will be in phase with the impressed E. M. F., *B*. In the following article it will be shown how a capacity unbalanced by inductance throws the current and impressed E. M. F. out of phase similarly to an inductance, but in an opposite direction.

To resume; when a current is increasing in value in a circuit containing an inductance, a counter E. M. F. is set up by the inductance, which acts against the impressed E. M. F.; this counter E. M. F. may be considered to set up a counter current which neutralizes part of the main current. When a current is decreasing in value, the inductive E. M. F. is in the same direction as the impressed E. M. F.; and the inductive current is added to the main current. The effect is that the main current arrives at its maximum value later than it would otherwise and also dies out later, thus causing the current to lag behind the impressed E. M. F.

On the other hand, when a current is increasing in value in a circuit containing a condenser, as the E. M. F. rises the two sides of the condenser become unbalanced, which sets up an additional flow of current, the unbalancing corresponding to an addition of voltage to the circuit, instead of a counter E. M. F. as in the case of an inductance; when a current is decreasing in value, the two sides of the condenser become unbalanced in an opposite direction and discharge into the circuit, thereby assisting the fall of current, the action again being the reverse of that of an inductance. As will be shown later, this causes the current to lead the impressed E. M. F. instead of lagging behind it, as in the case of an inductance.

SOME ELECTRICAL SPORT—1.

BY JAMES F. HOBART.

Almost any man feels better for having a joke once in a while, and the electrician is no exception to the old adage:

"A little nonsense now and then
Is relished by the best of men."

Electricity offers a vehicle for the conveyance of more uproarious fun to the square inch than anything else man is acquainted with, and it is very easy to rig up things in a dynamo room in such a manner as to more than astonish visitors that may drop in.

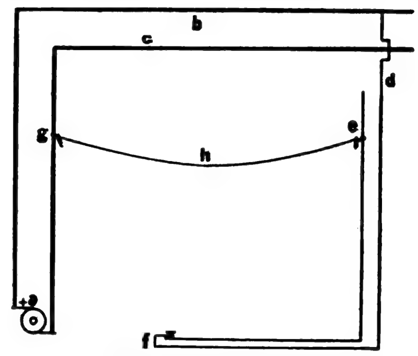
But this may be dangerous, especially where an arc-light current is used, unless proper precautions are taken, and the young engineer or electrician who is prone to practical electric jokes, should *never* try anything in this line that is new to him, unless he has first talked over the matter with an experienced electrician, and fully discussed the matter with him. Such a course may prevent accident, and the experiments will not lose anything by having competent advice given.

Some things may be done which form very striking illustrations of electric energy, and yet do not come strictly within the meaning of the words "sport," or "fun." In Fig. 1, let *a* represent an arc dynamo, and *b* and *c* the leads that pass to the lamps outside the dynamo room. Take off a branch wire as shown at *d*. Lead this wire to a convenient part of the room, and terminate it with the small hook shown at *e*. A switch, *f*, may be located at any convenient part of the room. In a rig put up by the writer, it was located in the floor, close to the engine where a man would naturally stand when attending to that machine.

The negative lead had its insulation removed at *g*, and another hook attached there. A piece of No. 36 copper wire was stretched from one hook to the other as at *h*.

The length of wire must be determined by experiment. If too long, the experiment will be unsuccessful. About 15 to 20 ft. will be about right for a first trial. Arrange the hooks so the wire will hang just above the head of the tallest man likely to come under it.

By closing the circuit at *f*, the current will flow through the fine wire and if the voltage is high enough, the wire will be burned with a flash like that of lightning. It forms a very striking experiment in the heating of conductors, and if 15 or 20 ft. of wire is



AN ELECTRIC FLASH LIGHT.

burned just above the heads of visitors, some of them, especially the ladies are apt to be heard from at once.

By putting in a wire heavy enough so that the dynamo cannot flash it instantly, the expansion of metals will become apparent, as the wire will sag 2 or 3 ft. when current is turned on, before it gets hot enough to burn. If the size and length of wire be gauged just right, current can be turned on, and the wire will stretch to its limit, and contract again when current is cut-off. Or, by making short contacts carefully, the fine wire can be stretched and contracted, and then burned with a flash at will. In a following article an account will be given of how some street urchins were cured of hanging around an electric light station.

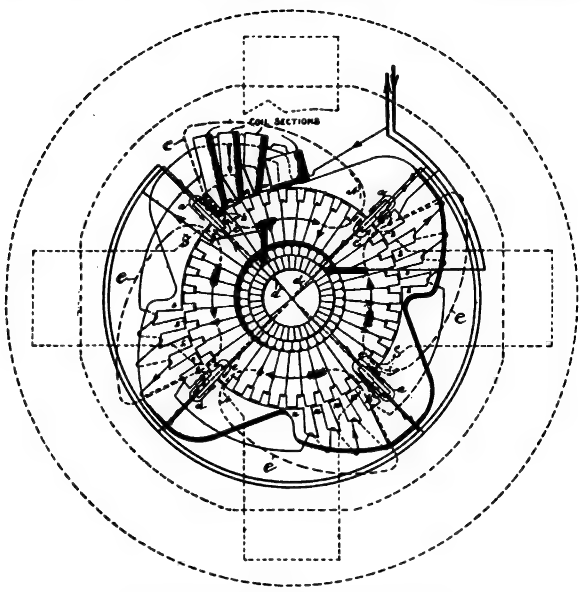
SOME NEW PRINCIPLES IN DYNAMO DESIGN.

In the present types of dynamo the field distortion, due to armature reaction, is combatted by the employment either of a large air gap, or oversaturation of the core teeth, or both, the object being to oppose as much reluctance as possible to the magneto motive forces of the armature, and thus resist or limit field distortion due thereto. Unfortunately, however, the reluctance obtained by these means is also opposed to the field windings.

These methods, therefore, necessitate the employment of large field coils and consequently of long magnet cores and a heavy ring or yoke structure. In spite of the large air-gap reluctance, more or less field distortion, according to load, takes place, thus necessitating a forward shifting of the brushes, which in turn weakens the field magnetism, and therefore imposes the necessity of using series or compounding coils, which still further increases the length of the magnet cores, and the amount of magnetizing energy, etc.

To overcome the above-named untoward conditions, Mr. Alfred W. Smith has recently patented a method whereby the field magnet coils are displaced from any neutral or commutating points, and wound in or across the flux paths of their respective magnets, and close to the armature, as shown in the accompanying illustration.

The argument of the inventor is that the magnetism generated by any given turn of a field coil must pass through that turn, though it need not necessarily pass through



NEW FORM OF DYNAMO FIELD.

all of the turns of the coil, but may leak out through the side of the coil adjacent to its own turn; it follows, therefore, that the magnetism generated by a field coil cannot be shifted forward further than the width of the coil.

It is then only necessary to wind the coils entirely back of the neutral lines, *a a*, and as close to the armature as practicable, to insure the desired reedom from field distortion; this is made possible by using a field-magnet structure which has on one side of its neutral points a single wide pole, or polar area, and on the other side thereof a plurality of smaller poles, forming between them coil-containing spaces (or instead of plural poles a single large coil space), in which space or spaces the coils are wound, as shown in accompanying diagram.

By this method of winding the field coils, a long external air path of very great reluctance is opposed to the armature magneto-motive forces, *b b*, thus obviating the present necessity for a large air-gap reluctance; the size of the air gap can, therefore, be made very small, while the core teeth can also have the same low reluctance as other parts of the magnetic circuit. The magnets, consequently, requiring only a small fraction of the magnetizing energy now necessary, and the coils being correspondingly smaller, consequently require proportionately less winding space; thus insuring a field-magnet structure which has about the same weight as the armature, or somewhat less, instead, as at present, being several times heavier. The dotted outline shows in contrast the ordinary form of field structure, consisting of cast-iron yoke ring with wrought-iron cores cast in.

The same patent contains a method to entirely prevent the spark causing self-induction, due to the rise or increase of current in the armature coils at the moment when their segments leave the brushes. This is accomplished by interlinking the coils at the moment when their segments leave the brushes—and when tending to produce self-induction causing magneto-motive forces, due to current increase, as represented by arrows, *c c*, with counter magneto-motive forces represented by arrows, *d d*, which, being equal or superior to them in strength, suppress those due to the armature coils, and thus prevent the existence of any spark causing self-induction in the commutable coils; thus insuring sparkless commutation, and enabling the use of metal brushes, which may be either solid, laminated or of gauze construction, and which remain in a fixed position for all variations of load and speed.

The absence of field distortion and sparking makes it possible to arbitrarily locate the position of the brushes when designing a machine for any given service, thus enabling any kind or amount of automatic regulation to be obtained by simply determining or fixing the constant ratio or proportion between the front and back armature turns interlinking with the field flux; thus enabling a machine to compensate for drop in engine speed, to have a rising voltage, as for railway work, or to have a falling voltage, as for some kinds of electrolytic work, without the use of any series or compounding coils.

For the same reason it is made possible to take full and complete advantage of all available means for increasing the carrying capacity of the armature, and, therefore, makes possible a proportionately greater output or effectiveness from a given size of armature.

The absence of field distortion and sparking also makes it possible to design high-voltage, direct-current machines for power transmission over long distances, thus securing higher efficiency, especially at part load, and lower first cost than is possible with the present-used methods; the absence of these defects also extends the speed limit, so that, in so far as difficulty from this source is concerned, the armature can be run up close to the mechanical or bursting limit, thus making it possible to obtain under these conditions a very large output per unit of weight and also very high electrical efficiency.

Letters on Practical Subjects

A Special Telephone Connection.

To the Editor of American Electrician:

The accompanying diagram shows two telephones connected so that conversation can be carried on from one to the other without having to call central to make connections. It should prove useful to a doctor or other person who has two telephones, one at his office and one at his residence, and wishes to talk with one or the other without each time calling up central. The material and apparatus necessary are a wire between the office and residence, and two 2-point switches and a telephone extension bell for each station.

The pair of switches are mounted on a piece of walnut board 3 ins. × 5 ins. with an insulated bar between the levers, as shown in the diagram, where the switch points are

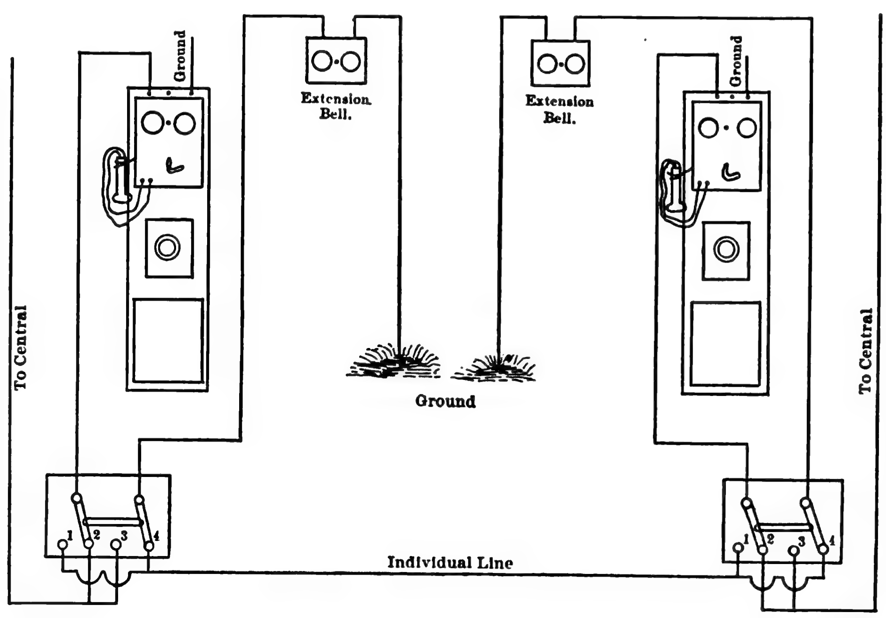


DIAGRAM OF TELEPHONE CONNECTIONS.

marked 1, 2, 3, 4. The lines from central are connected to the points 2-3 of the switches, and a wire run, as shown, from one of the two switch-levers to the line side of the telephone. A wire is then run between the stations and connected to the switch points 1-4; finally, a wire is run from the other switch-lever to one side of the exten-

sion bell, the other side of the bell being grounded.

The switch-levers of both stations must always rest on points 2-4 when the individual wire is not in use. When either station is to be called, the lever is moved to 1-3 which connects the telephone with the individual wire through point 1, and the extension bell with central point 3. Ringing up the telephone causes the extension bell at the other station to sound, and the party called moves the levers there also to points 1 and 3. Now both telephones are connected with the individual line, and central with the extension bells, so that should central have a call for either party, the ringing of the extension bell will notify him of the fact.

JAS. C. CONNAUGHTON.

Kansas City, Mo.

Methods of Calculating Joint Resistance.

To the Editor of American Electrician:

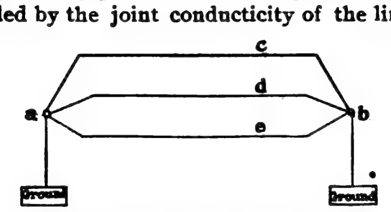
An electrician recently gave me a rule for calculating joint resistance which is quite ingenious and is correct. It is as follows: "Multiply all the resistances together; divide this product by each resistance in turn, and add the quotients. Divide the product of all the resistances by the sum of the quotients, and the result will be the joint resistance of the lines."

Suppose the three lines in the figure have resistances of: $c = 5$ ohms, $d = 10$ ohms, and $e = 15$ ohms. The joint resistance is required when the lines are connected in parallel, as in the diagram.

The operation carried out, is as follows:

$$5 \times 10 \times 15 = 750.$$
$$750 \div 5 = 150.$$
$$750 \div 10 = 75.$$
$$750 \div 15 = 50.$$
$$\text{Then } 150 + 75 + 50 = 275.$$
$$750 \div 275 = 2.8 \text{ ohms.}$$

This method is capable of a scientific demonstration, which proves that the principle involved in the method is correct. The reference books tell us that the joint resistance of any parallel circuit is equal to 1, divided by the joint conducticity of the line,



JOINT RESISTANCE OF THREE LINES.

and that the joint conductivity is equal to the sum of the reciprocals of the various resistances.

The resistance of wire c, is 5 ohms, its reciprocal is 1 divided by 5, or $\frac{1}{5}$. The reciprocals of the other resistances are $\frac{1}{10}$ and $\frac{1}{15}$. Then the joint conductivity of the duplex line will be: $\frac{1}{5} + \frac{1}{10} + \frac{1}{15}$. And the joint resistance will be 1 divided by that quantity, or

$$\text{Joint resistance} = \frac{1}{\frac{1}{5} + \frac{1}{10} + \frac{1}{15}}$$

The lower part of this reduces to

$$\frac{1}{\frac{150}{750} + \frac{75}{750} + \frac{50}{750}} = \frac{1}{\frac{150 + 75 + 50}{750}}.$$

It will be noticed that exactly the same numbers are arrived at here, as in the problem solved by arithmetic. Carrying out the solution, the last equation becomes

$$\text{Joint resistance} = \frac{750}{150 + 75 + 50} = \frac{750}{275} =$$

2.8 ohms. It will be seen that the two operations are identical almost, and that the arithmetical rule is the reciprocal method put into plain arithmetic. The value of the two methods is this: By the first method, the electrician has to proceed by an arbitrary rule, and once the rule slips his memory, he must look it up in his note book before the problem can be solved. The latter method gives the principle of the matter, and once familiar with that, the electrician can make up a rule as often as the old one slips his memory, and is not dependent upon memoranda for his data.

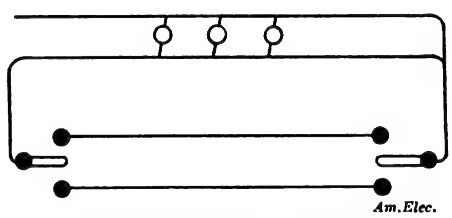
There is nothing mysterious about the calculation of joint resistances, as some people seem to think there is. The method outlined above is exactly the same as would be applied to the old questious found in any arithmetic, as for example: "One man can do a piece of work in five days, another man can do it in ten days, and another in fifteen days, how long will it take them all working together?"

Pittsburgh, Pa. JNO. L. HOLDEN.

"Double-End" Switch Arrangement.

To the Editor of American Electrician:

From practical experience, the writer is inclined to believe that the double-end switch arrangement given by Mr. Hobart in



DOUBLE-END SWITCH CIRCUIT.

the August number will be found objectionable, in that it brings both of the feed wires into each switch, thus making frequent trouble from short circuits. I think the diagram given herewith shows a method of wiring which overcomes this objection.

Rochester, N. Y. J. E. PUTNAM.

Stopping Motors.

To the Editor of American Electrician:

In the reply to an inquiry from "G. M." in the queries and answers department of your June issue, you state that the starting-box resistance in the armature circuit of a motor should be thrown into circuit *before* opening the main switch. This is true, provided one operation follows the other at a very brief interval of time—so brief as to make the movements practically simultaneous. But in ordinary practice it is far better to open the main switch first while the motor is running at full speed, in order that the counter E. M. F. of the armature may largely neutralize the inductive "kick" of the field. When the switch is thrown with the motor running, the resistance being all cut out of the armature circuit, the counter E. M. F. tends to maintain the excitation of the field magnet, and as the speed diminishes and the counter E. M. F. falls, the field magnetism is allowed to weaken gradually, minimizing the inductive reaction. The only inductive discharge occurring under these conditions is that due to the slight sudden diminution of the field excitation—the drop from the line E. M. F. to the armature counter E. M. F.—when the switch is opened. As a matter of fact, all automatic starting-boxes for motors are so constructed that opening the main switch causes the release of the rheostat arm and allows it to cut in the resistance, the latter operation *necessarily* following the opening of the switch.

New York. CECIL P. POOLE.

Some Shop-Cooling Devices.

To the Editor of American Electrician:

This hot weather is pretty hard on men in the repair shop who have to stand hour after hour at the bench or lathe, and cannot

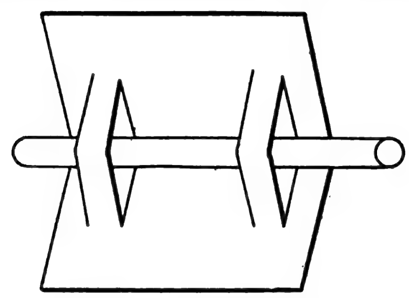


FIG. 1.—"FLUTTER WHEEL" FOR VENTILATING.

move an inch in order to take advantage of a bit of breeze that may chance to stray in. But with a little expenditure of time and material, a man can do a great deal to improve his condition while at work. If a lathe or a similar machine tool is standing idle, just stick an arbor into it, and on the arbor, or mandrel, put a sort of "flutter wheel," letting it run all the time the power is on.

Fig. 1, shows a wheel of this kind. It is, in fact, nothing but a piece of sheet metal cut and bent as shown in the engraving. Four cuts are made in the metal, parallel to each other, and a mandrel forced through. The spring of the metal keeps the thing on the shaft tight enough to stir up the air in a pretty agreeable manner all around it. Little paddle wheels can also be rigged on the largest step of the driving cone of a machine, and one man who had the best breeze in a whole shop, had a regular ship's propeller rigged on the spindle of his machine, just outside the main bearing. It might have been the vanes of an electric fan instead of a ship's propeller, and it probably was, for the protecting wires were there too, just as they are on a fan.

There are many places in a shop where the breeze don't penetrate even when it is windy without. In such a place, where there is some vacant space on the main shaft or one of the counters, put on a fanning mill as shown by Fig. 2. The bars are made of flat iron, about one-half by 2 ins., and bolted to the shaft as shown. Some very thin boards, or some No. 16 or No. 18 sheet iron or zinc, is riveted on the straps as shown,

and the whole business allowed to run when the engine is moving.

Half a dozen of these things in a room make a big difference in the comfort of the workmen, and have a very good effect on the quality as well as the quantity of the output. These fans or flutters should be made as large as will swing above the shaft, and as

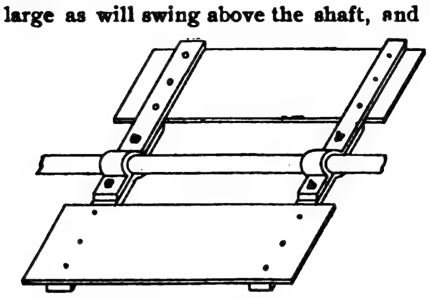


FIG. 2.—A COOLING WHEEL FOR THE MAIN SHAFT.

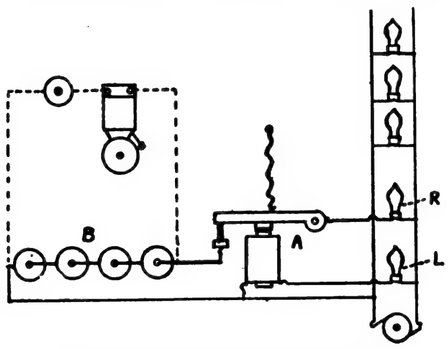
long as the pulleys will allow. Four or 6 ft. gives a good effect, but I have worked under one nearly 16 ft. long, extending from hanger to hanger, and nearly 5 ft. in diameter. It had four sets of iron straps fastened to it and to the shaft.

Brooklyn, N. Y. JAMES FRANCIS.

Dynamo Bell Ringing.

To the Editor of American Electrician:

I have read with great interest, the communication in your August number describing a method of operating bells, fire alarms, etc., from a dynamo current, with automatic switch for throwing on primary batteries whenever the dynamo stops running. It occurs to me that instead of primary batteries, your correspondent could profitably use a storage cell, thus making a more up-to-date installation and effecting



DYNAMO BELL RINGING CIRCUIT.

a decided saving, not only in running expense, but in first cost as well. The storage batteries, of course, cost more per cell than the primary battery, but as the available voltage is nearly double (2½ volts in the latest battery), he could do with four cells, work that would require eight of the best primary batteries. Besides all this, the storage batteries maintain their pressure at an almost constant point as compared with the primary.

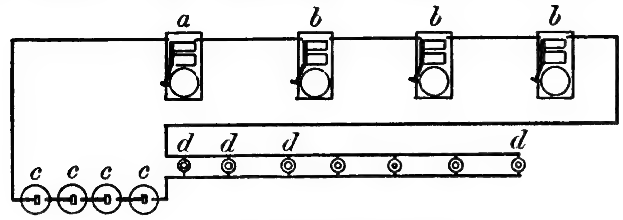
The diagram explains the connections by which the automatic switch, *A*, connected through a lamp or other suitable resistance, *L*, keeps the circuit closed through the battery, *B*, as long as the generator is running; when it stops the charging circuit is opened and the battery thus prevented from discharging through the dynamo. The signal circuit (represented in dotted line) is always in connection with the battery.

New York. CHAS. E. LEE.

Many Electric Bells in One Circuit.

To the Editor of American Electrician:

Frequently it is desirable to ring bells in different parts of a mill by pushing a single button. That is, more than one bell is to be attached in series (tandem) to a single battery. The engraving shows a case of this kind where four bells, *a*, *b*, *b*, *b*, must be rung from the battery *c*, *c*, and all the bells



MULTIPLE-BELL CIRCUIT.

must be rung at will from either of the several points *d*, *d*, *d*, *d*. Here the bells are in series and the buttons in multiple.

With ordinary electric bells, there would be trouble immediately from such an arrangement, because, owing to the probable difference in the springs of the several bells, they would not vibrate in unison, and when one bell struck and its spring opened the circuit, it would cut the current off from all the other bells.

But this very defect may be taken advantage of to make the bells, *a*, *b*, *b*, *b*, ring well. The point is, to make the bell, *a*, do all the interrupting for all the other bells and itself too. To do this, put up the four bells in the usual manner, then screw down the springs to the bells, *b*, *b*, *b*, until contact is *not* broken when the bells *b*, *b*, *b*, strike; then adjust bell *a* in the usual manner, and when the spr ng of this bell breaks the circuit, it acts for all the other bells in the circuit, and they will each strike at the same instant that the bell *a* makes a sound. The bells *b*, *b*, *b*, are thus virtually made into single-stroke bells.

San Francisco, Cal. J. K. TODD.

Dynamo Reversals of Polarity.

To the Editor of American Electrician:

As a careful and interested reader of AMERICAN ELECTRICIAN, I have noted the growing interest taken in the "Letters on Practical Subjects" department, and select this avenue, hedged with experience, as a road to valuable opinions on what is to follow.

Every station engineer has probably had experience in the line of dynamos, for some reason or other, occasionally reversing their polarity, and many of us have our theories, more or less incomplete perhaps, as to why this happens. When two or more dynamos run in multiple on the same bus-bars, and with their shunt fields all connected above the switches, the phenomenon is not so apt to take place, because in this case the polarity of the line dictates that of any machine to be placed in circuit, and this as soon as its field switch is closed; but if the polarity of the first machine started happens to be reversed, all fields connected to the same bus-bars and initially excited by this machine, will follow suit and the machines will run along together as amicably as if nothing had happened. If, under the above conditions, one machine's field circuit has, for any reason, been disconnected, and has, by mistake, been reversed in reconnecting, the line will charge that field so as to put its armature in series instead of in multiple, and unless the error is detected before closing the switch, trouble will ensue. If the error is detected in time, it will only be necessary to reverse the field leads, when, as soon as the field switch is closed, the line voltage sends a current which annihilates the former residual magnetism and charges the fields anew.

When the field leads are connected below the switch, each machine must generate its own field, and this field's polarity will depend upon that of the residual charge. We must right here impress upon the reader the fatality of confusing the effects of reversing the field connections of a machine with the effects of merely reversing its residual magnetism. A machine, if properly connected, can generate a field of either polarity, for

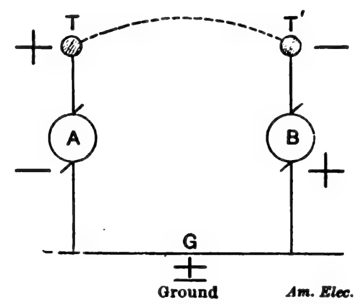


FIG. 1.

polarity of the field developed depends solely upon that of the residual magnetism, whereas, if a self-exciting dynamo, properly connected, have either its field or armature leads reversed, it will not generate at all.

When the polarity of a self-exciting dynamo is found to be reversed, matters can be righted, as far as concerns the line, either by reversing the bus-bar connections or by recharging the fields. On arc-light machines the former or its equivalent is done, because

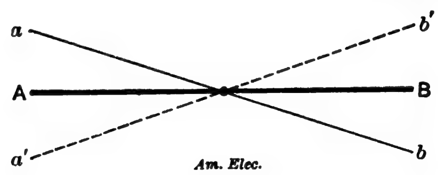


FIG. 2.

it is more convenient, while on constant-potential dynamos, it is customary to recharge the fields.

On arc machines, whether isolated or run in series with others, it is necessary to have proper polarity, because, in the first case, the lamps would burn upside down, throwing all the light upward; in the second case, the reversed machine would spark (from its

brushes being out of position) momentarily, until current from the other machines recharged its fields.

Of constant-potential machines running in multiple, it is almost unnecessary to say that they must be of like polarity; but when isolated (barring electroplating and cell charging) it makes a difference only in exceptional cases, of which the following is one: In a certain Southern town, were two street railway power houses, feeding entirely different roads, and each power house had a single generator, one of whose terminals was grounded, the other terminals going to the respective trolley wires. One, which we will call *A*, had a negative trolley and positive rail, while the other, *B* (see Fig. 1), was the reverse. All went on smoothly till one excursion day when traffic was heavy, *B* was short of power and undertook to borrow a little from *A* by making the connection TT' shown in the dotted line; the result was to place the two dynamos in series across the short circuit-*A-T-T'-B-G-A*.

These reversals have been attributed to the so-called "extra current" which obtains when a field circuit is broken; this cannot be so, because the extra or induced current at breaking is of the same polarity as the primary, and tends to maintain the existing field. No doubt, as some say, many reversals are due to stray fields of neighboring machines, and possibly to errant lightning discharges, but neither of these explains the reversal of isolated machines under a clear sky. The writer is inclined to explain the phenomenon as a result of a molecular friction.

All magnetic metal is composed of small particles; in a normal state these particles have a certain general direction, indicated by line *A B* of Fig. 2. When subjected to magnetic influence, the particles deflect, say, to the general direction, *a b*, which we will call positive. If the magnetizing force be now suddenly removed, the particles will swing back toward *AB*, but their momentum will carry them past the normal or neutral line, *AB*, to a position $a'b'$ (which is the general direction that the particles would have taken up had the magnetizing force applied been negative); and the molecular force which is strong enough to hold them in their normal direction ordinarily, is not strong enough to overcome molecular friction and start them on a swing back to *AB*, so their polarity remains slightly reversed.

This theory has not, as far as the writer is aware, been advanced before, and therefore lacks the support or reputation of authority, but we would be pleased to have the pros and cons of the readers.

Omaha, Neb. S. T. COMSTOCK.

A Peculiar Phenomenon.

To the Editor of American Electrician:

During a recent storm in Macon, Ga., a man in one of the stores there, while using a telephone, was hurled backwards and knocked insensible by a discharge of lightning. The man was badly shocked, and did not recover for several days. But the part which I would like to have explained through your columns is this: The diaphragm of the hand 'phone was pressed, by some force from the outside, against the core of the magnet, the coil and the inside rim of the hard-rubber piece, with such force that it conformed exactly to the shapes of the different parts against which it was pressed, and remained just in that shape. The pressure was uniform, for the diaphragm was not warped or dented in the least, but took the exact shapes on every part of it.

Could it have been caused by the creation of a vacuum on the inside, or was the force created and exerted from the outside? The lightning arresters at the instrument were not burnt out, and the inside of the hand 'phone was not hurt at all. The damage to the man and to the diaphragm was the only injury done.

Atlanta, Ga. A. L. TORRANCE.

ELECTRICAL CATECHISM

155. Is not the energy of an alternating current equal to the product of amperes by volts.

Sometimes it is, but usually is not. When there is no lag between the current and voltage, that is, when the waves of current and pressure reach corresponding values simultaneously, both being at zero at the same time and both being at positive maximum or other corresponding values at the same time, the simple product of amperes by volts gives watts. This is illustrated in Fig. 1, which represents a circuit without induction, such as a group of incandescent lamps, in which the current is in phase with the voltage. The energy at any

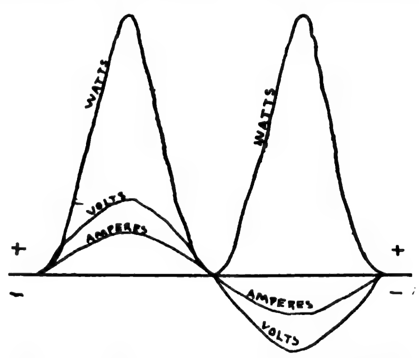


FIG. 1.—CIRCUIT WITHOUT INDUCTANCE.

instant is the product of current by voltage at that instant. The upper curve is plotted from the products of corresponding values of current and voltage. The area enclosed between the watt curve and the base line represents the energy in the circuit. In the second part of the cycle, the current and voltage are both negative, but the energy is positive, since the product of two negatives is always positive.

156. How can the energy of an alternating current be different from the simple product of amperes by volts?

If the circuit has self-induction or capacity the current waves are behind or ahead of the voltage waves, and the true energy is less than the simple product of volts by amperes. This is illustrated in Figs. 2 and 3, which have current and voltage curves, equal to those of Fig. 1, but which have different watt curves. If the curves of current and voltage are not in the same phase, one will sometimes have a positive value when the other is negative, the result being that their product is negative for part of each

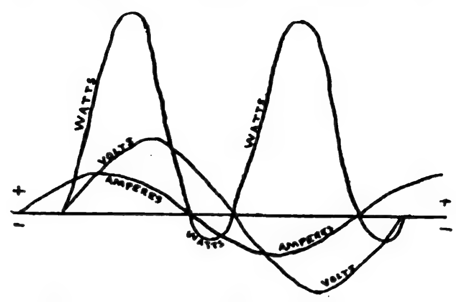


FIG. 2.—CIRCUIT WITH INDUCTANCE.

cycle, as shown in Fig. 2. The area of the loop on the lower side between the base line and the watt curve represents negative energy, that is, energy that is returned to the line or source of supply.

157. How can a line deliver current or energy back to a generator?

Sometimes the pressure on the line may exceed that on the generator and so force current back. A somewhat similar analogy is that of a simple-acting steam engine having high compression. The energy of the fly-wheel may raise the pressure at the end of the exhaust stroke above the initial steam pressure.

158. How can an alternating current be wattless or without energy?

This would occur in the extreme case when the current and E. M. F. curves are 90 degs. apart, one being at zero when the other is at a maximum, as indicated in Fig. 3. The negative loop in the watt curve exactly equals the positive loop, and the line returns as much energy as it receives. This

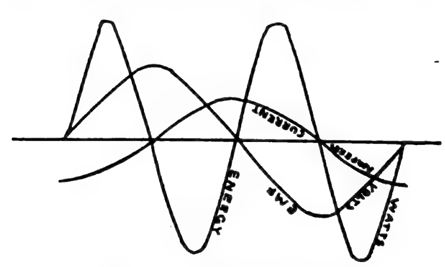


FIG. 3.—WATTLESS CIRCUIT.

condition never happens, but is closely approximated when a circuit has great self-induction and small resistance as in the case of the primary coil of a transformer when the secondary circuit is open.

159. Is it correct to say that part of an alternating current is wattless and that the rest has energy or power?

Yes. The whole current may be considered as being made up of two parts, one being in phase with the E. M. F. and one being 90 degs. behind it. In other words, although there is only the one current, it may be thought of us being resolved into components whose sum properly taken equals the whole. This is strictly analogous to the composition and resolution of forces.

QUERIES AND ANSWERS

NOTE. *Criticisms and extensions of the answers given in this column will be welcomed. Windings of amateur motors and dynamos cannot be supplied, as such designs rarely justify the labor required for the calculation; the complete series of designs of small machines now being published in this journal will usually furnish data for other small machines, if intelligently applied.*

What is the method of locating a leak in a submarine cable? C. R.

See Kempe's "Hand-Book of Testing."

How is pole-finding paper made? J. H. S.

Add one part of iodide of potassium to ten parts of distilled water, and moisten filter paper with the solution.

1°. How many cells of storage battery would be required to run a 20-foot launch at a moderate speed for six hours. 2°. What substance has its electrical resistance changed by light? A. A. A.

1°. See p. 292, July issue. 2°. Selenium.

What are Hertzian waves, how are they produced and what peculiar properties do they possess that make them capable of transmitting electrical energy without wires? L. E. M.

See editorial in August issue.

How can a 500-volt shunt-wound generator be run as a motor on a 110-volt circuit? N. C. M.

Not very satisfactorily without rewinding. Throw the fields in parallel; also throw adjacent armature coils in parallel, short-circuiting the segments by pairs.

What is the object of condensers on two-phase motor circuits? How are they connected? H. W. Y.

To counteract the inductance of the motor. (See "Lessons" in this issue). They may be connected in series or in parallel—usually the latter.

What is a static transformer? W. N. T.

Static transformer is a trade or shop name used for the ordinary transformer for stepping voltages up or down, to distinguish it from the rotary transformer, which is used to convert alternating into continuous currents, or vice versa.

How can I strengthen horse-shoe magnets? R. E. B.

Place the legs across a dynamo pole gap, a leg resting on each pole. If the gap is too wide, place a piece of soft iron on each pole, the ends being separated by a distance equal to that between the magnet legs, and place the latter in contact with the ends.

Please give a diagram of the equalizing connections of two-phase alternators in parallel? K. H. J.

An equalizing connection is only used when the machines are compounded, and then it is applied in the same manner as in the case of compound direct-connected machines.

Why is salt sometimes used in the porous cup of the Fuller cell? J. R. B.

A saline solution may be used instead of sulphuric acid as an excitant. Slater used salt with a nickel electrode to obtain a residue having a commercial value—the double chloride of sodium and nickel.

How can three storage cells be charged from a 117-volt circuit? H. B. S.

Cut the cells at a fuse block into one leg of a main, the cells being in parallel. The main should have six 16-CP lamps for each ampere of charging rate. The cells in circuit will not affect the brightness of the lamps noticeably.

A socket on a 117-volt circuit in which six lamps burnt out in three months was replaced by a new one, and a lamp in the latter has been burning six months. How is this accounted for? H. B. S.

The only reason that suggests itself is that the old socket may have heated badly from a loose connection, thus deteriorating the lamp. This, however, seems little probable.

Why are the frames of arc-light dynamos grounded? J. P. G.

To dissipate static electricity generated by the belt, it is much better to insulate the frame from the ground and collect the static electricity from the belt by means of a grounded metallic comb. Underwriters' rules require a resistance in circuit of not less than 200 ohms per volt generated when the frame is grounded.

1°. How is a burglar alarm connected so that the alarm will ring when a wire of the circuit is cut? 2°. Please give instructions for making a storage battery. E. P.

1°. A current from a closed-circuit battery (such as blue-stone cells) always passes through such a circuit when in operation. The alarm bell is worked from a relay in the closed circuit. The burglar protective devices are normally closed, the relay causing the bell to ring when a circuit is opened. 2°. See p. 68, February issue, and p. 178, May issue.

What resistance is used in the construction of a high-grade voltmeter, reading up to 500 or 600 volts? T. B.

High-grade voltmeters have usually a resistance of 50 ohms or over per volt of full capacity. Three Weston instruments examined have resistances as follows: 600 volt, 56,180 ohms, or 93.65 ohms per volt; 600 volt, 75,902 ohms, or 126.5 ohms per volt; and 1000 volt, 127,420 ohms, or 127.42 ohms per volt. Weston voltmeters are also built with 200 ohms per volt, on special order.

1°. How is zinc alloyed with mercury? 2°. Does amalgamation change the E. M. F.? J. H. C.

1°. Warm the mercury and plunge it to the bottom of a pot of melted zinc by means of an iron spoon. Pour the alloy immediately afterwards. For large quantities of zincs, cast a rich alloy of one part mercury and two parts zinc in the above manner, and add pieces of this gradually to the melted zinc. 2°. The E. M. F. is very slightly increased. The object of amalgamation is to prevent local action.

1°. What are the starting rheostat resistances for 1, 3, 5 and 10 HP 500-volt motors? 2°. What regulating resistances are required for dynamos? 3°. What resistance should a speed regulator for the above motors have? H. J. D.

1. 300, 100, 60 and 30 ohms, respectively. 2°. From one-third to one-half that of the field; the exact resistance depends upon the characteristic of the machine and the range of regulation. 3°. About the same as the starting resistance; the exact resistance depends upon the design of the machine, nature of load and range of variation desired.

How can I make an electromagnet to lift 5 lbs. through 6 ins.? F. G. O.

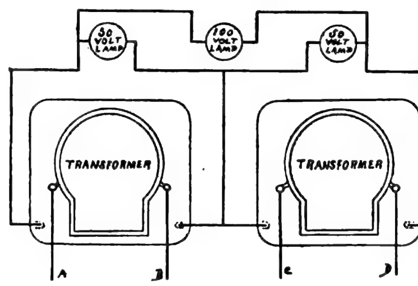
Use a system of levers such that the magnet armature will not need to travel through more than, say, ¼ in. This will be equivalent to a lift of 120 lbs. at the armature. A horse-shoe form of magnet should be used, made of 1½-in. round soft iron. Determine the ampere-turns by trial, using a trial coil of, say, 500 turns of No. 16 wire. The size and length of the final winding will depend upon the source of current with which the magnet is to be used, its ampere-turns being fixed as above.

1°. Is it necessary to transpose the two wires of of a metallic-circuit telephone line if there are no other wires on the poles? 2°. Is it necessary to transpose the wires of such a circuit if a grounded line is carried on the same poles? 3°. Would running a second wire through a disturbing neighborhood, and transposing it with the wire of a grounded circuit, obviate inductive trouble on that circuit? M. L. C.

See articles on the telephone line in the June and August issues. 1°. To prevent disturbances from the earth's field, as during magnetic storms, the metallic circuit should be transposed. Practically, the advisability of doing so is doubtful on short lines. 2°. A grounded line will exert an influence on a metallic circuit, the same as will any other circuit carrying a variable circuit; if in close proximity, it will be necessary to render the metallic circuit non-inductive by transposition. 3°. Yes; see article on page 236, June issue.

Please give a diagram of synchronizing connections for two-phase alternators? K. H. J.

The connections are shown in the accompanying diagram. To synchronize any two circuits, connect *A* and *B* to one phase of one circuit and *C* and *D* to the corresponding



phase of the other circuit, *A* and *D* being connected to terminals of the same polarity. When the two circuits are in synchronism the middle lamp will be extinguished, as it will then connect two points at the same potential.

What insulation resistance per lamp should an interior wiring for incandescent lighting have? J. N. C.

Following are the underwriters' requirements, which control:

The wiring in any building must test free from grounds, *i. e.*, the complete installation must have an insulation between conductors, and between all conductors and the ground (not including attachments, sockets, receptacles, etc.), of not less than the following:

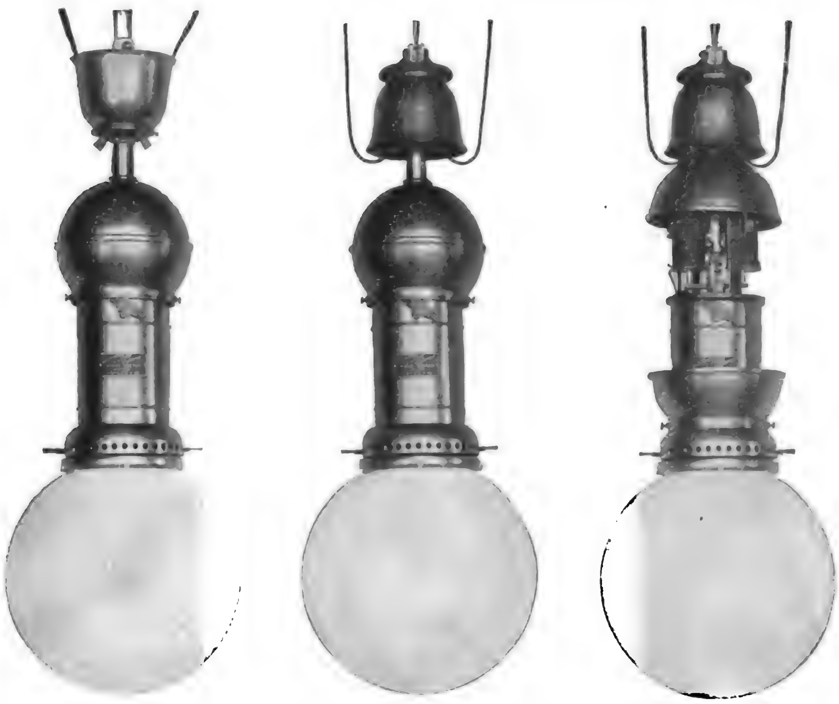
Up to	5	amperes	4,000,000 ohms.
"	10	"	2,000,000 "
"	25	"	800,000 "
"	50	"	400,000 "
"	100	"	200,000 "
"	200	"	100,000 "
"	400	"	50,000 "
"	800	"	25,000 "
"	1,600	" and over	12,500 "

All cut-outs and safety devices must be in place for the above test. Where lamp sockets, receptacles and electroliers, etc., are connected, one-half of the above is required.

New Apparatus and Appliances.

NEW 150-HOUR ENCLOSED ARC LAMPS.

A new design of enclosed arc lamp has been placed upon the market by the Western Electric Company, which in several respects is a new departure from previous types.



WESTERN ELECTRIC 150-HOUR ENCLOSED ARC LAMPS.

The large spherical globe is suspended entirely from the top and is without a lower opening; this, together with the arrangement of the inner globe and its means of support, results in a highly efficient distribution of the light from the arc over the area where it is most needed, at the same time securing a uniform and pleasing illumination of the entire globe. For trimming, the globe is readily lowered, being held in the lower position by projecting arms attached to the side arm of the lamp; the inner globe, together with its lower carbon holder, can then be removed for trimming, or be replaced by a fresh inner globe and lower holder already trimmed, the upper carbon having first been put in place.

The regulating mechanism, while of the simplest construction and requiring a minimum of energy to operate, is very effective and controls the voltage and current of the arc with such nicety that great steadiness and constancy in the light result. The lamps are equipped with either series or shunt-controlled regulating mechanism as desired, so that they can be operated either singly on a constant potential of 110 volts, or a number in series upon higher potentials. Where a number are used in series an automatic cut-out is supplied, which, upon the consumption of the carbon in any one lamp of the series, will operate to extinguish the lamps and prevent injury.

All lamps are equipped with spring-actuated switches, making a large, quick break which precludes the possibility of the formation of a persistent arc at the switch. These switches are also adapted to be operated by a simple pushing movement which may be communicated by a pole, by which they can be reached from the floor.

By a special arrangement the rheostat and canopy containing the rheostat are adapted for either outdoor or indoor use, as shown in the illustration, slight change only in the arrangement of these parts being necessary to fit it for either use. This change can be made in a few minutes.

The carbons used are solid, ½ in. in diameter, 12 ins. for the upper and 5 ins. for the lower. After the lamp has burned 150 hours, there is still enough of the upper carbon left to be used for a lower in retrimming.

FEED-WATER HEATERS.

The types of Bundy feed-water heaters have recently been increased by adding one having an oil-separating section, called "Style B," and another of horizontal pattern, called "Style C." The oil-separating section of the former is shown in Fig. 1. The exhaust upon entering the heater encounters a curving plate having a grooved face, which conducts the oil and grease the separator has withdrawn from the steam, to the bottom of the section, from which it finds egress through an oil drip-pipe. The grooved plate is convex instead of straight in order to increase the separating surface by the difference between the arc and the chord, and to give a deflecting impingement at the point of contact. The grooves are diverging to convey the oil beyond the exhaust opening, to which it cannot return against the intermittent current of the steam. Openings level with the floor of this section are supplied through the baffle for the oil to escape to a drip-pipe by the action of gravity.

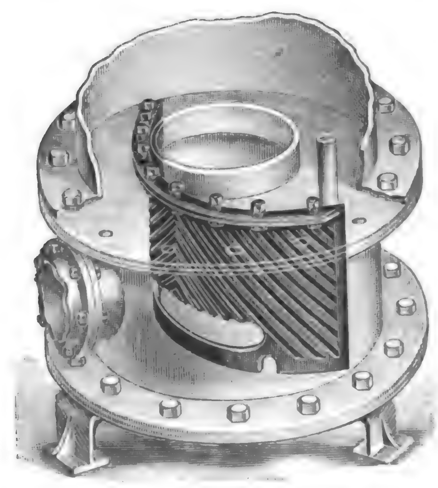


FIG. 1.—OIL-SEPARATING SECTION OF BUNDY FEED-WATER HEATER.

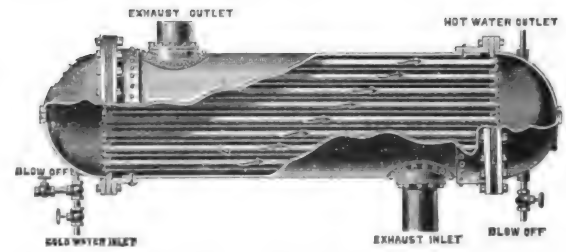
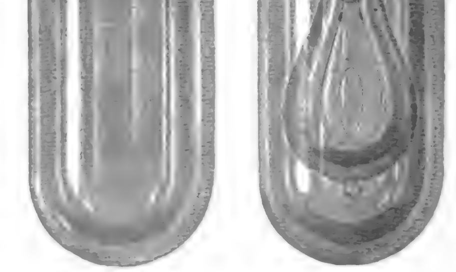


FIG. 2.—HORIZONTAL BUNDY FEED-WATER HEATER.

The dome-shaped ends of the horizontal Bundy feed-water heater (Fig. 2) are practically the only changes that distinguish it from the vertical style. Like it, the heating surface consists of the exteriors of a nest of brass tubes, seamless and of two-inch size. Each tube has one end rigid and the other end movable to allow for expansion and contraction, thus obviating leverage straining. The water and exhaust inlets and outlets, blow-offs, hand-holes, etc., are provided with a single purpose looking towards convenience in use. The above described heaters are made by the A. A. Griffing Iron Company, 66 Centre Street, New York.

WATER-PROOF RECEPTACLE.

The receptacle illustrated is a combination of a water-proof socket and a water-proof globe, a single piece of porcelain forming a socket for the lamp and for the cover of the globe. The conducting wires are permanently sealed in the porcelain cap, which is threaded into the receptacle, and the glass globe and rubber gasket in the cover make a



WATER-PROOF RECEPTACLE.

water-tight fitting between the cover and the globe, thus enabling the outfit to be used under water with perfect safety.

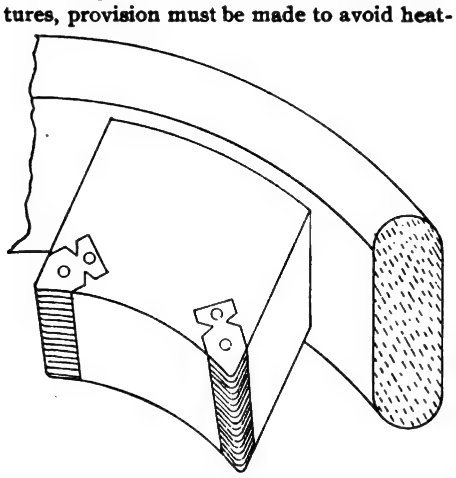
This appliance finds its largest field of usefulness in breweries, packing houses and similar work where it is customary to wash the floors, walls and ceilings with showers of water. It will also be found to offer a solution for all places where severe conditions have heretofore made a perfect insulation of lamp and socket an impossibility, such as cold storage warehouses, paper mills, etc.

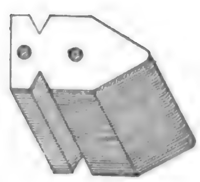
The receptacle is made regularly with T.-H. base, but can be used with an Edison lamp by the use of a T.-H. adapter. The globe will take either a 16 or 32-CP lamp, the opening in the globe being 2¾ ins. The length of the globe is 6 ins., while 7 ins. is the length of the outfit over all.

The Newgard water-proof receptacle above described is made by the Electric Appliance Company, of Chicago.

NEW METHOD OF LAMINATING POLE-PIECES.

In large machines with toothed armatures, provision must be made to avoid heating due to eddy currents set up in the pole-pieces, and with solid poles this heating is so great that it is necessary to have a large clearance, which reduces the capacity of the machine and wastes copper and energy in the field coils. Most makers to-day overcome the difficulty by making the entire poles of laminated iron bunched together and cast solid into the field ring, which, though effective, is costly.





NEW METHOD OF LAMINATING POLE PIECES.

It is well known that the heating of the poles is chiefly, if not entirely, at the corners or edges. In a dynamo it is at the edges from which the teeth are being drawn, and in a motor the edges to which the teeth approach, and it, therefore, occurred to Mr. S. W. Rushmore that it was necessary to laminate only the corners where the heating takes place.

Fig. 1 shows the new method, with laminated sections cast into the corners of the poles. Fig. 2 shows a bunch of the iron punchings used. It will be seen that there is a great saving in labor and material over laminating the entire poles, while very few tools are required, as one size punching may be used for a number of sizes of machines.

This method, which has recently been patented, is used in all the large machines built by the Rushmore Dynamo Works, of Jersey City, N. J., and is claimed to be fully as effective as when entire poles are laminated, while the clearance may be made as small as desired.

IMPROVED RÖNTGEN-RAY APPARATUS.

A new line of Röntgen-ray-generating apparatus has recently been placed upon the market by Queen & Company, of Philadelphia, of which we illustrate herewith the two principal details—the induction coil and circuit breaker.

In designing the new line of coils (Fig. 1) careful attention has been given to proportioning the different parts. The distribution of the wire on the secondary was determined by measuring the discharge from single coils of a few turns of wire placed at intervals throughout the field of the primary. From the data obtained by these tests, curves were plotted showing the proper distribution of wire for coils of all sizes. Similar methods were used to determine the size and number of turns of the primary and the amount of iron in the core. In insulating, methods are employed which remove absolutely all air from the insulating material of the secondary. By this means danger of the coils breaking down is obviated, and small leaks, which diminish the efficiency and may develop in time into serious breaks, are prevented.

The induction coil illustrated in Fig. 1 has neither vibrator nor condenser, being intended for use with an adjustable condenser and independent vibrator described below. The spark points are adjusted by the hard-rubber disk shown at the left of the base, which is so well insulated that the operator is in no danger of receiving a shock even when the points are opened out to the full extent. The coil is finished throughout in polished mahogany and hard rubber.

The vibrator, which is a very much improved form, is shown in detail in Fig. 2. The movable platinum contact is carried on a small vertical spring behind the vibrator spring. When the contact is made the movement of the vibrator is not arrested as in other forms, but continues to its full amplitude, thus allowing a long "make." The length of the "make" can be varied by screwing in or out the other platinum contact. The most important advantage of this arrangement is the suddenness of the "break," which is accomplished by the collar in the vibrator spring striking the movable contact while at full speed. In the old forms of interrupters the break was made when the vibrator started to move, consequently it was not only much slower, but did not make use of the momentum of the iron head of the vibrator. Sometimes the welding action of the current joined the two pieces of platinum so tightly that the magnetic pull was not sufficient to separate them. In the new form, as the break is made when the vibrator is at the middle of its swing, the sudden blow with the entire momentum of the vibrator head is always sufficient to break the platinums apart, and once started, the vibrator continues in motion until the current is turned off. The suddenness of the break makes it possible to use this form of vibrator on the 110-volt as well as battery circuits; it also adds very

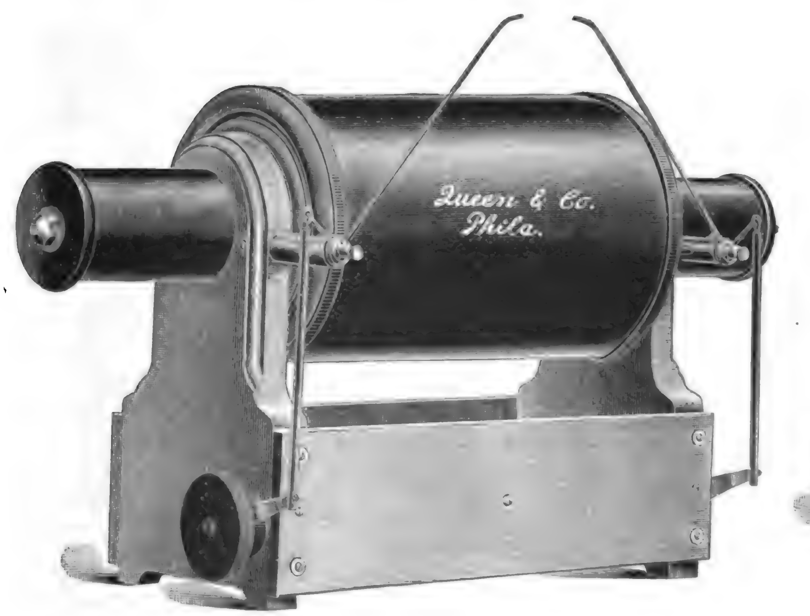


FIG. 1.—INDUCTION COIL.

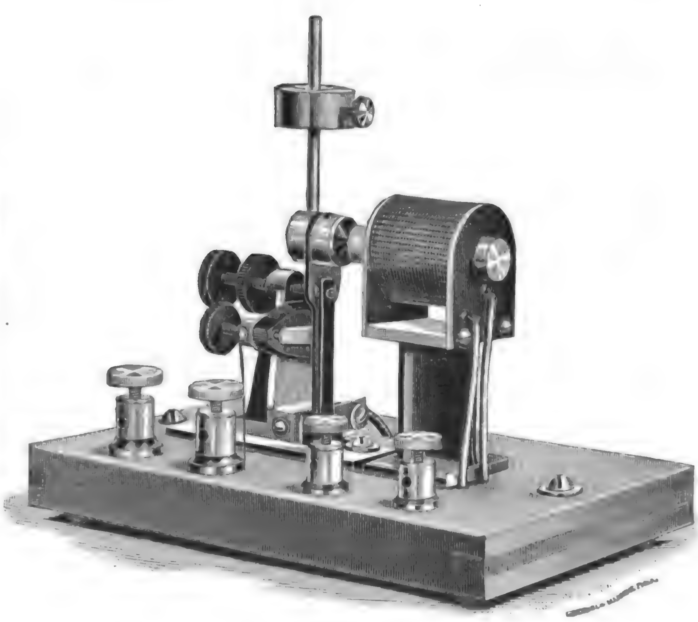


FIG. 2.—VIBRATOR.

greatly to the efficiency of the induction coil with which it is used.

A rod screwed into the iron head carries a weight, which may be moved up and down and clamped in any position with a set-screw. By this means the rate of vibration may be varied within wide limits. To summarize, the new vibrator has the following advantages over older forms: Its action is independent of the current going through the coil; its rate of vibration is adjustable; it permits of a long "make," and the length of the "make" and "break" is adjustable; the "break" is very sudden, increa ing the efficiency of the coils, and making it thoroughly adapted to the 110-volt circuit; it never sticks.

The outfit complete for X-ray work consists of a coil mounted on a base, with rheostat, if used for a 110-volt circuit, and with an adjustable condenser and independent vibrator mounted on the same base. In addition to this, a number of tubes, a suitable stand, fluoroscopes, etc., are included with each set.

NEW BALL ENGINE GOVERNOR.

Recent developments in connection with electric lighting in office buildings, insist on such exacting service as to allow only the minutest variation of speed under widely varying loads and changing pressures. Not only must the speed be uniform, but it must remain so during the period of the change. To meet these new and rigid requirements, the Ball Engine Company, Erie, Pa., has, after months of experiment, perfected a governor which fulfills the demands referred to, with the additional advantage of extreme simplicity in construction.

NEW BALL ENGINE GOVERNOR.

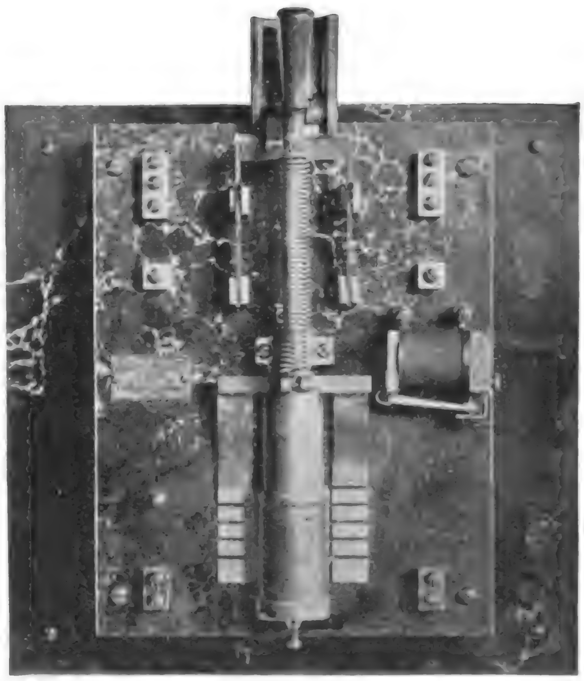
This governor, which is an adaptation of the Rites inertia governor system, regulates not only for the slightest variation of speed, but does so with a very rapid adjustment and without the slightest instability or surging. This has been practically impossible with governors having a multiplicity of connections, all in rapid rotation, under heavy strains, and in many cases with improper lubrication.

Technically stated, the centrifugal element upon which the degree of the refinement of regulation of all governors depends, is combined with an inertia element, relatively so great that instant and extreme changes of load are immediately provided for without waiting for the otherwise necessary manifestation of centrifugal force.

The entire governor consists of but a single moving piece, suspended upon one pivotal point, thereby reducing the friction to a minimum, and with no joints to interfere with the best action of the governor. The suspension pin or pivotal point is made of hardened crucible steel. The suspension pin eye is lined with phosphor bronze, and the little lubrication that is required is accomplished by forcing grease by means of a compression grease cup, into a number of recesses arranged around the bore of the bushings.

"PERFECTION" RHEOSTAT.

The rheostat illustrated herewith consists of a double-pole knife switch, a fuse block, a release magnet, an overload magnet and an automatic circuit breaker, all mounted on one slate front. The operator closes the switch, pressing the handle somewhat, which brings a plate connected with the switch in contact with the stem of the plunger, and thereby removes the pressure from the latch. This being done, the magnet immediately draws the latch over, and on letting go of the handle of the switch, it is retained by the latch if there is current in the fields; otherwise it will not catch the latch. If the switch is retained, the resistance is automatically cut out of circuit. If an overload occurs, the overload magnet acts and releases the switch, thereby opening the double-pole knife switch. If from any cause the resistance is cut out of circuit when the knife switch is open, it is impossible to close the switch. If on closing the switch the current is excessive, the overhead magnet will simply prevent the cutting out of resistance until the current drops, when the latch will retain the knife switch, and the resistance will be automatically cut out of circuit.



"PERFECTION" RHEOSTAT.

With this rheostat, known as the "Perfection Rheostat," and made by the American Rheostat Company, Milwaukee, Wis., the usual knife switch, fuse block, circuit breaker, accompanying switch-board and connections are all done away with.

ELECTRIC GAS LIGHTER.

The accompanying cut illustrates an electric gas lighter and burner which is operated in the same manner as the ordinary gas-key burner. A quarter turn of the key opens the gas-cock and operates the arm which creates a spark to ignite the gas; a partial reverse motion serves to diminish the size of the flame and a full quarter turn to extinguish it. While the manipulation of the burner is very easy and simple in comparison with that of the ordinary pendant burner, the greatest advantage is in the impossibility of a short circuit occurring during its operation. This is obviated by a simple device which causes the movable electrodes to pass under the fixed electrode when the gas is being extinguished without making contact.

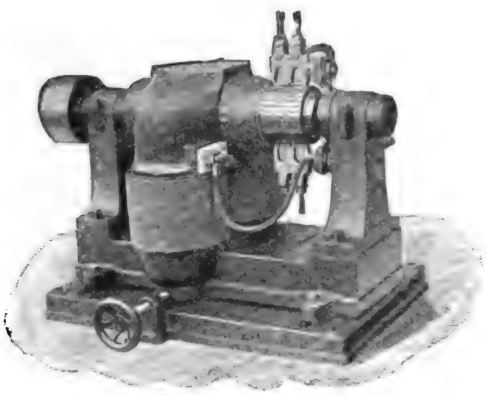
The mechanical details have been carefully considered, resulting in the production of a burner which is strong, well made, requires no oiling, and is not affected by dust. The burner is now manufactured in the following styles: Straight stem as illustrated, side lever, straight stem and side-lever candle, and straight stem and side-lever argand. The stems are made in different lengths. Insulating bushings are also fitted to any of these styles, which do not increase the length of the burner. The manufacturer of the "Advance" burner above illustrated and described is the Electric Gas Lighting Company, 193 Devonshire Street, Boston, Mass.

"ADVANCE" BURNER.

ECK DYNAMO AND MOTOR.

The accompanying illustration shows the Eck dynamo and motor, which is of the drum type with tooth armature core. The field magnets are of wrought-iron of high magnetic quality, being cast into pole-pieces almost enclosing the armature, the field cores being cylindrical in form.

The armature core is built up of insulated laminated iron disks, and is perfectly balanced, to insure noiseless operation. The wire, which is embedded in mica, is completely beneath the surface and covered with plugging strips of mica or fibre, which are securely bound on by bands. The commutator, which is of tempered copper, is unusually generous in size, thus being specially fitted for carbon brushes. The bearings are of the self-oiling type and do not require attention oftener than two to four weeks. The bushing in which the shaft runs is of phosphor bronze, and rests in a ball joint, thus securing perfect alignment.

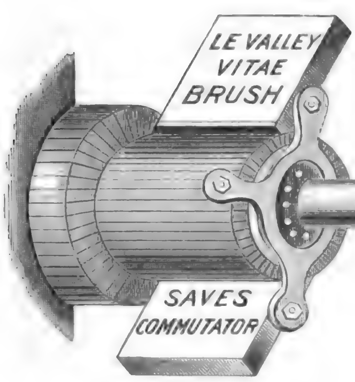


ECK DYNAMO AND MOTOR.

The sales agents for the Eck dynamo are Goldmark & Wallace, 29 Chambers Street, New York.

VITÆ DYNAMO BRUSH.

One of the faults of so-called self-lubricating dynamo brushes is that they are apt to gum the commutator. The Vitæ brush, shown in the accompanying illustration, is claimed to be entirely free from this reproach and to have other merits peculiarly its own. The brush is made of a special grade of carbon of a definite porosity. In treatment the gases are extracted from the carbon, the pores of which are then filled with a substance entirely free from grease and animal oil. After this treatment the brush lubricates constantly and uniformly as it slowly wears away, never crumbling or cutting, and insuring at all times an even, bright and polished surface. In using the brush the commutator becomes somewhat discolored, but this is not due to any oily or gummy substance on the surface; the discoloration can be easily wiped off with a rag, when the surface of the commutator will be found much brighter, smoother and cleaner than is possible with the usual brush. The wear of the commutator is almost imperceptible, and being uniform, no sand-paper or turning down is required. One of the claims of the brush is that it will outwear any ordinary carbon brush.



VITÆ DYNAMO BRUSH.

The makers, we may add, have received strong endorsement of their claims from firms that usually do not give recommendations of the kind, such as Otis Bros., the C. & C. Electric Company, the Sprague Electric Elevator Company, etc. The Vitæ carbon brush is manufactured by the Le Valley Vitæ Carbon Brush Company, 39 Cortlandt Street, New York.

VOLO MICROPHONE.

The microphone illustrated in the accompanying engraving is claimed to require a much smaller amount of battery than is generally used in transmitting speech, while, on the other hand, reproducing speech as clearly and with as natural a tone as if the person talking were standing directly by the receiver and conversing in an ordinary tone of voice. Another claim is that the telephone will not pack or get out of adjustment, these difficulties of ordinary telephones having been effectually overcome in this type.

VOLO MICROPHONE.

On short lines not using an induction coil, one cell or battery gives ample volume of sound. On lines using an induction coil it is claimed that one cell will give the same results as two cells with other instruments. Great care is taken in the construction of the apparatus, it being built solid and substantial and graceful in form.

The Volo microphone is made by William M. Snyder, 218 Mill Street, Germantown, Philadelphia, Pa.

Interurban Electric Railway.

Work on the long-heralded railway between Cleveland and Akron, O., has commenced. Contracts have been let for the grading of the road bed.

NEW BOOKS.

TABLES AND FORMULAS FOR ELECTRIC RAILWAY ENGINEERS. By E. A. Merrill. 128 pages. Price, $1

The second edition of this useful work has received some additions and is bound with blank pages interleaved. The data and tables here collected can be relied upon, which is far from being the case with the usual hand-book. A number of the tables and formulas are original with the author, while many others have been modified and extended to adapt them to the conditions imposed in electric traction work. Two features of the work that will be appreciated are tables of common and hyperbolic logarithms. The tables on sag in span and trolley wires will be found of particular value, being compiled from the result of actual tests.

THE ALTERNATING-CURRENT CIRCUIT. An introductory and Non-mathematical Book for Engineers and Students. By W. Perrin Maycock, New York: The Macmillan Company, 102 pages, 51 illustrations. Price, $1.

This little volume will be found a useful book for beginners of the study of alternating-current phenomena, though it goes to an extreme in the employment of mechanical analogies. If the reader, however, will not confound the electrical phenomena with those illustrated by mechanical devices, and consider that springs, weights, vanes and stop-cocks merely furnish crude and incorrect representations of the electrical actions they are intended to explain, he will derive much benefit from the reading of the book, which also includes considerable practical information on choking coils, etc.

FUEL AND REFRACTORY MATERIALS. By A. Humboldt Sexton. New York: D. Van Nostrand Company. 352 pages, 104 illustrations. Price, $2.

In this volume the subject of fuel is dealt with in a comprehensive manner, the preparation of artificial fuels in particular being treated at length. The subjects of chapters are combustion, heating power of fuels, fuels—wood, peat, coal, solid prepared fuels—charcoal peat and charcoal coke, coal-washing, liquid fuels, gaseous fuel, recovery of by-products, furnaces for metallurgical purposes, supply of air to the furnace—removal of waste products—smoke—prevention of smoke, pyrometry, calorimetry, utilization of fuel, testing fuels, refractory materials—bricks—chimneys. While the book is written principally from the metallurgical point of view, the information collected in the several opening and final chapters are of direct interest to the engineer.

A SYSTEMATIC TREATISE ON ELECTRICAL MEASUREMENTS. By Herschel C. Parker. New York: Spon & Chamberlain. 120 pages, 100 illustrations. Price, $1.10.

The contents of this volume appeared originally in serial form in the late *Electric Power*, the object of the writer having been to treat the subject of electrical measurement in a more systematic manner than had previously been done. All of the usual methods of measurement of electrical quantities are given in classified order, and the most desirable ones, or those most applicable to a particular case, are pointed out. The theory of measurements are but briefly referred to, but the arrangement of apparatus and details of manipulation in measurement are concisely illustrated and explained. The work should prove useful to the student, as the explanations are in simple form, mathematics beyond arithmetic being rarely used.

ELECTRICITY AND MAGNETISM. By Eric Gerard. Translated from the fourth French edition by R. C. Duncan, under the supervision of Dr. Louis Duncan. New York: The W. J. Johnston Company. 392 pages, 112 illustrations. Price $2.50.

Gerard's "Lecons sur L'Électricité" has long been a standard work in the French language, and has also been largely used as a reference book in American college courses. Its value lies in an extreme lucidity of style and the logical method of development adopted, which render it the most easily read of any book covering the same ground. To the student who wishes to take up the study of electricity in earnest, and who has an elementary knowledge of the calculus, this book can be confidently recommended as the one in whose reading

he will encounter the least difficulty. The treatment, while not intending to be practical, is much more so than the typical college text-book, and furnishes an excellent preparation for the higher technical study of the science. The English translation has its value much enhanced by the addition of a chapter on hysteresis by Charles Proteus Steinmetz, a chapter on impedance by Drs. Houston and Kennelly, and a chapter on units and dimensions by Dr. Cary T. Hutchinson.

TRADE PUBLICATIONS.

Rheostats. The American Rheostat Company, Milwaukee, in a recent circular illustrates and describes its "Perfection" starting rheostat, the direction accompanying which is "Close the switch and the rheostat does the rest."

Drop Forgings. The Keystone Drop Forge Company has issued a catalogue of the standard drop forgings of its manufacture, which includes 148 articles or parts of articles, including machine handles, eye-bolts, hooks, and many forms of wrenches.

Wire. The John A. Roebling's Sons Company, of Trenton, N. J., has recently issued a comprehensive catalogue giving the advantages of the wire manufactured by this company, in electrical construction. A number of very interesting tables and results of tests are given.

Paints. The Joseph Dixon Crucible Company, of Jersey City, N. J., has published a neat pamphlet comparing the merits of lead paints and Dixon's silica graphite paint. This pamphlet has been issued to answer the claims of red lead manufacturers that the use of carbon, especially graphite, is injurious.

Bliss School of Electricity. The Bliss School of Electricity, Washington, D. C., has issued in the form of a handsomely illustrated pamphlet, its announcement for 1897-98. Among the many engravings contained are illustrations of a number of pieces of apparatus made by students, practical work in this line being one of the features of the school.

Machine Tools. Catalogue No. 33 of the Newton Machine Tool Works, Vine and 24th Streets, Philadelphia, contains 180 octavo pages, of which the first 42 are devoted to late designs of milling machines alone, the older designs occupying many pages in addition. One of the specialties of this firm is the design and manufacture of electrically driven machine tools of every description.

Switches. No less than seventy-five pages are required by the Western Electric Company in which to catalogue, illustrate and describe the switches of its manufacture. Among the features of the catalogue are numbered detail engravings of switches, with reference to a code table whereby the smallest part can be designated without chance of error, and dimensioned engravings of larger switches for the convenience of switch-board constructors.

Machine Tools. The Garvin Machine Company, Spring and Varick Streets, New York, has issued an artistically executed pamphlet giving well executed half-tone interior views of its new building, which is probably the handsomest structure in the world used for the construction of machine tools. About forty views are given of different departments, including the electric plant, which supplies power for lighting, driving the machinery, and operating two freight and one passenger elevator.

Presses, Roller Bearings and Special Machinery. With the title of "A Model Plant and what It Produces," the Mossberg & Granville Manufacturing Company, of Providence, R. I., has issued an octavo catalogue containing no less than 230 pages. Of special interest to those engaged in electrical manufacturing are the long line of presses and the many forms of roller bearings, illustrated and described. Every factory and repair shop should have a copy of this handsome and useful pamphlet for reference.

Engines and Boilers. James Leffel & Company, of Springfield, O., have issued a 40-page catalogue (Pamphlet D) of the line of engines and boilers of its manufacture. The details of the engines, such as valves, governor, etc., are well illustrated and accompanied by technical descriptions. The thirty-five years' experience of this well known company in manufacturing power machinery has afforded it unusual opportunities for ascertaining and keeping pace with the requirements and improvements in the steam power line, the result of which is embodied in the line of steam machinery to which the pamphlet is devoted.

Enamel Rheostats. The ninth catalogue of the Ward Leonard Electric Company contains forty-four large-size pages devoted to field, motor-starting, dimming and fan-regulating rheostats, motor-reversing controllers and regulating rheostats, enamel resistance plates, automatic circuit breakers, etc. The catalogue is a comprehensive one, giving detailed descriptions and illustrations of all the various apparatus included, together with a code word for every size and type. It is just five years since the first enamel rheostats were placed on the market by this firm, and their use since then has become so general, both at home and abroad, that at present several hundred types are standardized. The firm is represented in England by the Veritys, Limited, and in Berlin by S. Bergmann & Company.

BUSINESS NEWS.

Arc Lighting. The city of Niagara Falls asks for proposals for arc lighting, the announcement to this effect appearing in our advertising columns.

The Ohio Telephone Construction Company, originally the Ohio Harrison Telephone Construction Company, has had its corporate name altered as above, the word "Harrison" being dropped.

The Babcock & Wilcox Company advises us that the motion for injunction in the suit of Cahall *vs.* Babcock & Wilcox has been decided in favor of the latter in the United States Court for the Western District of Pennsylvania.

Electric Furnace Litigation. The Carborundum Company, Niagara Falls, N. Y., has had a decision rendered in its favor, in the suit brought by the Cowles Electric Smelting & Aluminum Company against the Carborundum Company, in the United States Circuit Court, Western District of Pennsylvania, some three years ago, for alleged infringement of the Cowles patents, through the use of the Acheson electric furnace.

Messrs. Shureman & Hayden, No. 303-6 Dearborn Street, Chicago, report that they are in receipt of many good orders in the line of repairs. This firm has built up an enviable reputation for A-1 work, and parties doing business with it once, invariably give it succeeding orders. The work this company does on winding and building commutators is strictly first-class, and every piece of work turned out is guaranteed.

A New Orleans Contract. Messrs. Schminke & Newman, of New Orleans, have been awarded the contract to fit up the new St. Charles Hotel annex with electricity, against some fourteen bidders, some of whom came from St. Louis, Chicago and New York. Messrs. Schminke and Newman secured this contract over all competitors because of the completeness and specified details of their bid. Iron-armored conduit is to be used throughout.

The Chicago Insulated Wire Company, No. 152 Lake Street, Chicago, tells us that it is well satisfied with the prospects for a good fall business in wire, as the orders it has already booked indicate a speedy return of sound, substantial business. It also states that it is doing a heavy business for this season of the year in electric-light wire, which, it believes, tends to show that reconstructing, extending and new building have begun in earnest.

Mr. William Wright, formerly manager of the Chicago Armature Company, has severed his connection with that firm and has accepted the position of general Western agent for the E. G. Bernard Company, of Troy, N. Y. Mr. Wright has the best wishes of a host of friends throughout the West and Northwest, and the E. G. Bernard Company is to be congratulated over the acquisition of Mr. Wright's services in this capacity. Mr. Wright has opened an office at 939 Monadnock Block, Chicago.

Electrical Magic. The Pacific Electric Company, La Crosse, Wis., has obtained possession of a very clever device called "the electrical trick" by which a piece of money can be made to disappear in the most mysterious manner, that the most clever person will fail to detect how this may be accomplished. The company uses it to advertise its shade lamps and dental lamps, and will be pleased to send one of these tricks to any one who will write for same and will enclose four cents in stamps to cover cost of mailing.

Glass Hanger Board. To Mr. W. B. McDonald, superintendent of the People's Light & Power Company, Chicago, must be given the credit of producing an arc-lamp hanger-board, made entirely of glass, having a glass back or support, as well as glass insulating knobs. The device, which is known as the McDonald glass hanger-board, can consequently always be relied upon as a perfect insulator, and always looks bright and clean. This specialty is being placed on the market by the Electric Appliance Company, Chicago.

Mr. Walter C. McKinlock has established himself in the electrical supply line with an office in Fort Dearborn Building, Chicago, and is prepared to introduce in the West first-class lines of merchandise or specialties. Mr. McKinlock has a large personal acquaintance with most all the station superintendents, owners and contractors in Chicago and the West, and with fifteen years' experience on the road and well posted in the art of advertising, should be a valuable man for those seeking a Western outlet for their goods.

Bill Poster Advertising. We notice that the A. A. Griffing Iron Company, 66 and 68 Centre Street, New York, is liberally advertising its heaters with bill posters 9 ft. 4 ins. high × 14 ft. long. They are gotten up in three colors, orange, black and red, and show the Bundy sectional tubular heater, interior view, very effectively in connection with the fire in red. In New York City alone it has 150 of these posters and at all summer resorts there is a liberal distribution of them. We understand that it is the intention of the A. A. Griffing Iron Company to carry out this policy pretty extensively throughout the country.

The Keystone Drop Forge Company. American and York Streets, Philadelphia, has purchased the entire plant and all its appurtenances, of what was formerly known as the Philadelphia Drop Forge Company, prior to its transient connection with the late King Drop Forge Company. An agreement has been entered into with Mr. A. Morris Hall, who has been actively associated with the business for the past six years, whereby he is given general charge of the same, and under his management patrons can feel assured that all dealings with the company in the future will be conducted in a manner that will insure complete satisfaction.

A Straw. That the electrical trades are benefiting from the current revival of business is indicated on every hand. As an instance we may note that the factory of the Crouse-Hinds Electric Company, of Syracuse, has recently commenced running nights in order to keep up with orders for Hinds patent tubular switches. Central and power stations that had been allowed to get out of trim during the recent depression are now being renovated, neglected switch-boards are being put in shape, and needed improvements added—in fact, a general cleaning up has commenced that will favorably affect every branch of the electrical trade, aside from the business from extensions and new plants.

The Standard Underground Cable Company, of Pittsburgh, gives the following guaranty to its customers: "Our attention has been called to the somewhat extravagant pretentions put out by interested parties, wherein claim is made, in substance or effect, of an exclusive patented monopoly of paper-insulated electric cables and wires. We have been manufacturing and selling wires of that kind for many years, and, under advice of counsel, we have no doubt whatever as to our right to do so. We therefore advise you that as regards any such wires and cables which you may purchase from us, we will be prepared at any and all times, at our own charge and expense, to defend any suit or suits brought against you for infringement of the patent referred to, we to be promptly notified of such suit or suits, and to be allowed an opportunity to make defense therein."

American Electrician.

Vol. IX. New York, October, 1897. No. 10.

THREE-PHASE SWITCHBOARDS.

THREE-PHASE SWITCH-BOARDS, APPARATUS AND SYNCHRONIZING METHODS.

BY H. E. RAYMOND.

When designing and constructing switch-boards for three-phase alternators, it is well to remember that in general arrangement they are not unlike those of simple uniphase alternators, and that simplicity should be the main idea kept in view. A board intended for the control of but one generator it is needless to describe in detail. It is just as well, however, to call attention to the fact that due consideration should be paid in the plan to having plenty of room, no unnecessary wiring and apparatus fully capable of controlling the current and voltage to be used. The conditions of service under each case form individual problems, but in a general way the few cases described here will be found to cover most of the ordinary requirements.

The first thing, after the general system of distribution has been decided, is to settle upon the number of generators, feeders, lines, etc., necessary to the work to be accomplished. It should be settled definitely just how the load is to be apportioned and transmitted. Should it be decided to throw the entire load on one transmission line, it would usually be planned to run direct-connected generators and parallel them on one set of bus-bars. If there are to be more than one set of transmission wires, the generators should be so controlled as to make it possible to place them on any set of bars either alone or in multiple. The accompanying sketches will give enough of an idea as to the connections, to enable one to work out any more complicated arrangement of feeders.

Fig. 1 represents the wiring and connections of the switch-board of the Baltic Power Company, at Baltic, Conn. As the plan is drawn in such a manner as to indicate as clearly as possible the general principles of the board, all instrument arrangement is eliminated in order to obtain greater simplicity.

This wiring was gradually evolved, not as the result of any laborious study, but simply as it became evident that the temporary trial arrangement and apparatus would not answer. The method of operation is such that generator *B* carries a nearly constant load, and transmits it over feeder *B*. The

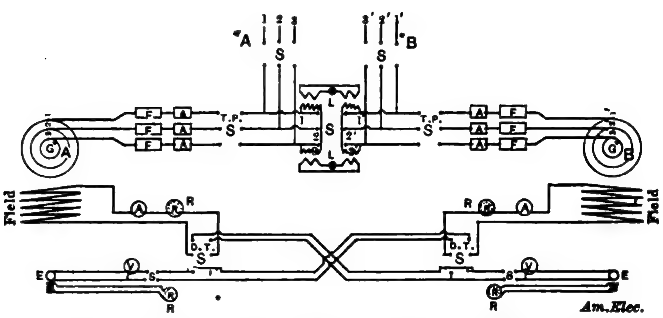


FIG. 1.—WIRING AND CONNECTIONS OF THREE-PHASE SWITCHBOARD.

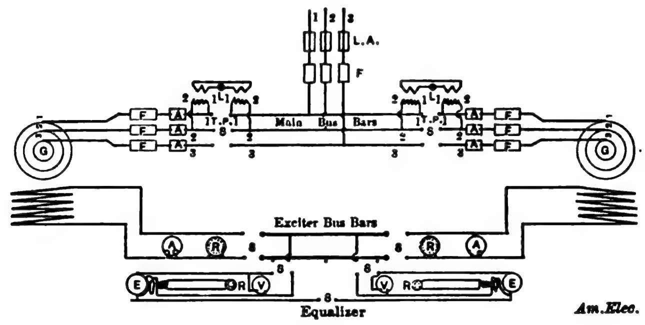
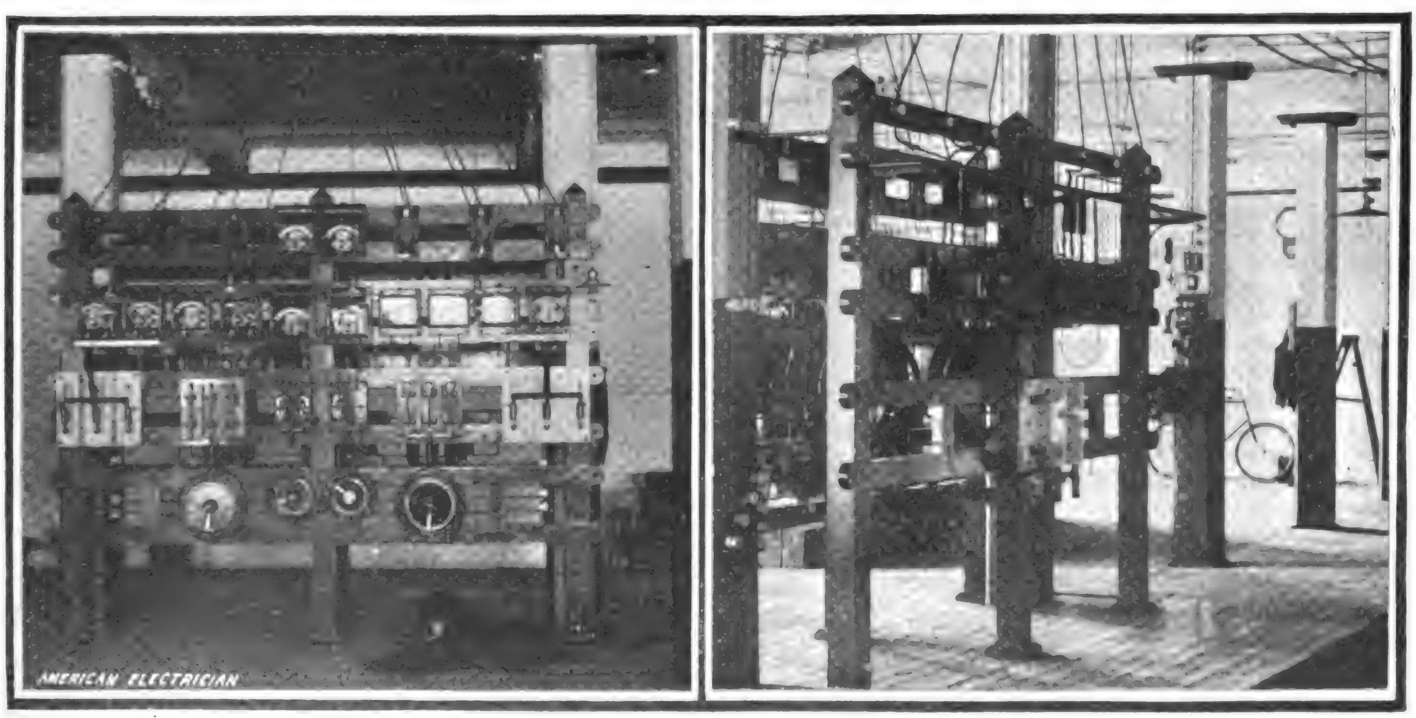


FIG. 2.—CONNECTIONS OF TWO THREE-PHASE GENERATORS.



FIGS. 3 AND 4.—REAR AND FRONT OF THREE-PHASE SWITCHBOARD.

other generator, *A*, carries a railway load, which fluctuates within very wide limits. Feeder *A* carries this load and all such as are very variable. The other line is utilized for the operation of all loads that are fairly constant, such as lamps, etc. The voltage is only partly regulated on line *A*, but is carefully watched on line *B*. If it is desired to run but one generator, it will be seen to be possible to supply either or both feeders from either machine. The two generators may be run in parallel on the combined load, or may be merely synchronized long enough to shift the load. The connections of the synchronizing transformers are shown in detail in the central part of the illustration. When synchronizing single-phase alternators by this method, two transformers are needed for each pair of machines, or one each if there be more than two. Let us consider any two wires from both machines, as No. 1 and No. 2, on each generator, to be single-phase (as, of course, they are). Then 1 and 1′ are connected to the primary terminal of a transformer having a rated voltage equal to that across the lines. Care must be taken that the corresponding terminals are used. That is, the terminals which are to be connected directly together should have the same instantaneous value of potential, either positive or negative. The other terminals are to be connected to the other wires, as 2 and 2′. The secondaries are connected through a lamp in such a manner that the terminals electrically opposite 1 and 1′ of the primaries are together and those opposite 2 and 2′ are together. When the generators are in phase, it will be seen that 1 and 1′ will be positive or negative at the same instant, and the E. M. Fs. of the secondaries oppose each other. Under these conditions the lamp will, of course, be dark.

As a three-phase generator armature consists of practically three single-phase coils, it is necessary that some means be employed to determine when the coils on two machines will be in phase, or if these coils are connected in such a manner as to produce the same direction of phase rotation. In this case another transformer connected across any other two wires on each machine, with primary and secondary wiring connected as in the method just described, may be used. If all the coils (corresponding coils) come into phase, the lamps should glow and darken in unison. In the Baltic station there are not used, as will be noticed in Fig. 1, two pairs of transformers, but only one pair. The following method is used to determine whether or not the other coils will come into phase:

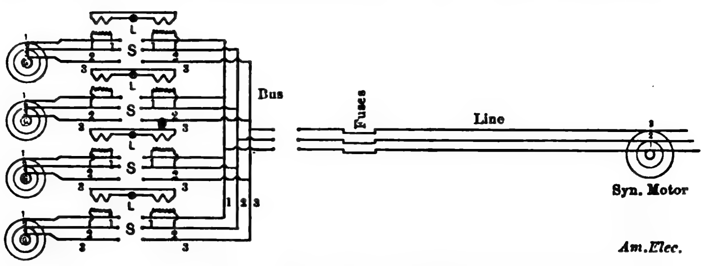


FIG. 5.—ARMATURE CONNECTIONS OF FOUR THREE-PHASE GENERATORS.

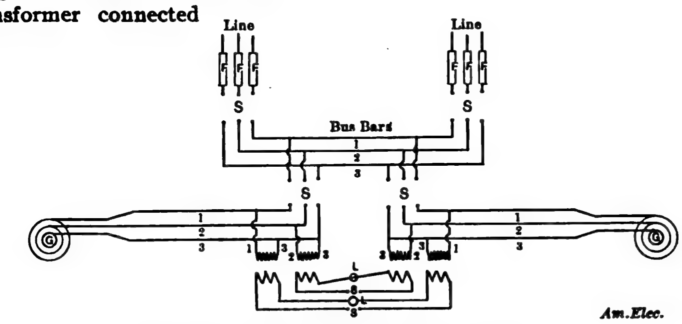


FIG. 6.—SYNCHRONIZING CONNECTIONS.

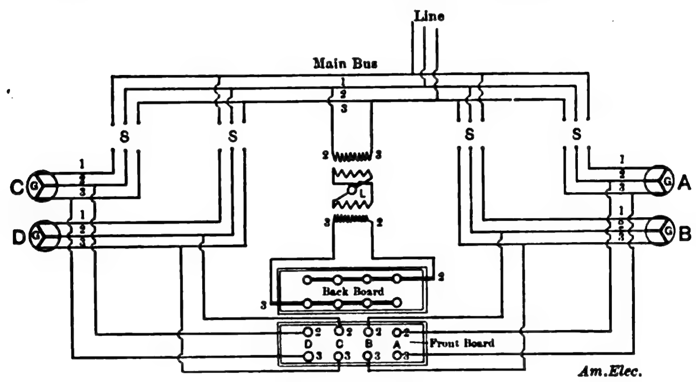


FIG. 7.—SYNCHRONIZING CONNECTIONS.

A synchronous motor is started up from one feeder by current from one generator and the direction of rotation is noted. The same performance is gone through with, using the other generator over the same feeder. The direction of rotation indicates phase rotation and if it is the same as in the first trial, the phase rotation will be the same, and the generator may be run safely in parallel.

This trial, of course, need be made only when generators are first started up, after installation or repairs and perhaps might be made but once in the life of a machine, except as more were added. When this is once made and the direction of the torque known, the machines may be synchronized at any time with but one pair of transformers. It is very important that the proper terminals be linked together and that their coils be correctly connected. If one of the transformers has connections reversed, the lamp will glow when the lines are in phase and this departure from custom will tend to unnecessarily complicate operation and attendance. Custom has decided that phase indicators should show a dark lamp when the machines are in step, and it is preferable to abide by this. Probably the reason for this lies in the fact that it is possible to judge more accurately the moment of complete extinction of a lamp, than the moment of greatest brilliancy.

The exciters in this plant are, as shown, intended to supply current, each for the field of its own alternator, but they are so connected that, in an emergency, one

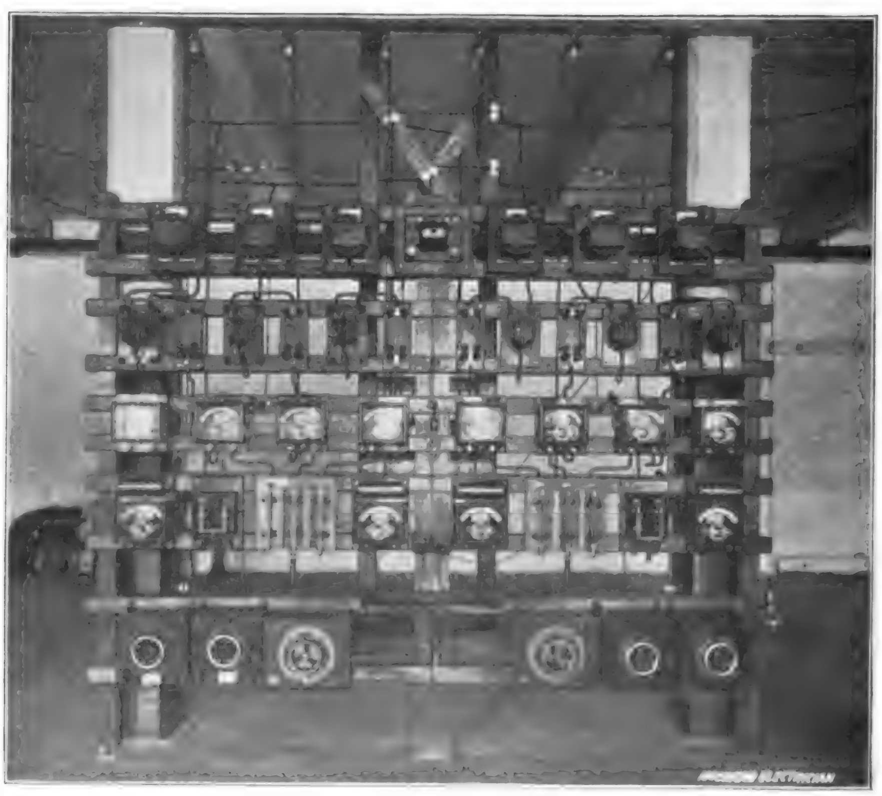


FIG. 8.—ORIGINAL SWITCH-BOARD FOR TWO THREE-PHASE GENERATORS.

may be thrown on to both alternator fields.

Fig. 2, shows two generators supplying current to a common bar, and to common feeders. The method of synchronizing is the same as above, except that the single source of demand simplifies the connections. For example, one machine starts a motor, at the substation, in a certain direction and is then shut down. The other machine is thrown on the bars and the motor again started. If its rotation is as before, the machines are all right as to phase. The common bar makes it less likely that a cross-connection occur, as might be the case with the cross-over switches in Fig. 1.

The arrangement of exciters is different in that either exciter is capable of exciting the fields of both generators, and is usually so operated. Connecting to a common bar, to which the terminals of both fields are run, makes it possible to run in multiple or shift the load in any manner. This plan of using a single exciter for all the generators has many advantages. The principal one to our mind lies in the fact that the voltage of every generator may be simultaneously varied or regulated by varying the voltage of the exciter. This will prove a valuable feature when machines are running in parallel and sudden overloads come on, or under similar conditions.

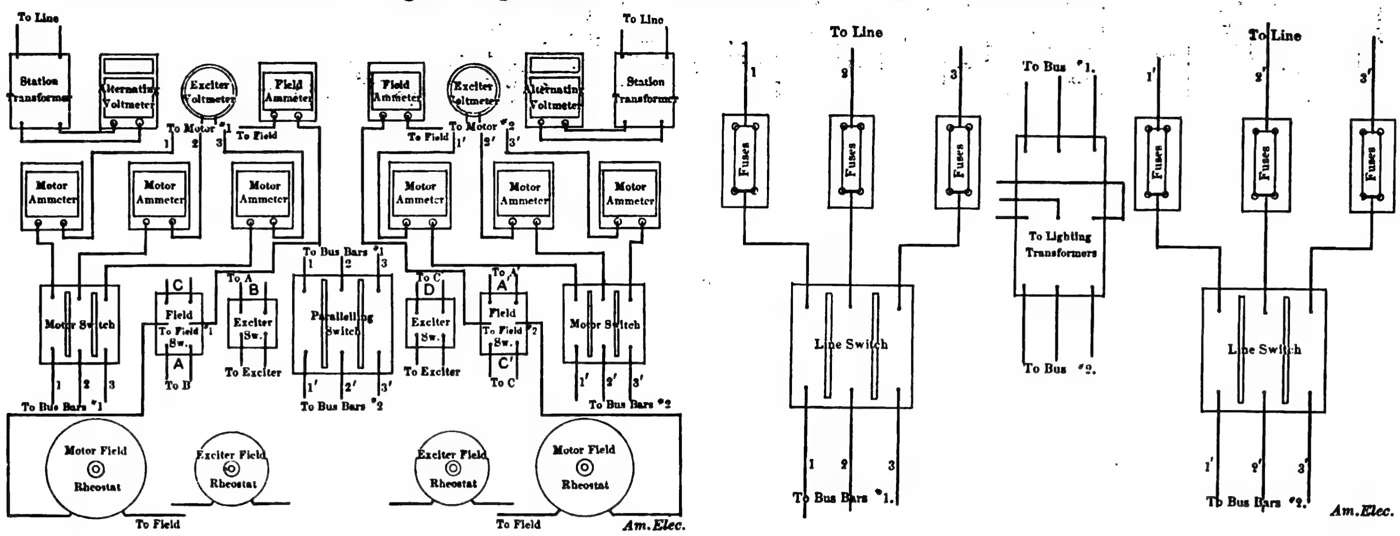


FIG. 11.—ARRANGEMENT OF MOTOR SWITCHBOARD.

Fig. 5 represents merely the armature connections for four generators supplying current to a common bar. The synchronizing transformers are shown as connected to the bus-bar, and the wires from the generator which are to be coincident with the bars.

In Fig. 6 are shown the synchronizing connections in enlarged detail. The two generators are run either each alone or both in parallel on the bus-bars. Any number of feeders may, of course, be switched on these bars. This method is to be used when the load is such that motors may not conveniently be employed in order to determine the direction of phase rotation.

It will be noticed that no lightning arresters are shown, and that all safety catches are called "fuses." The first omission was intentional, made to avoid a possible suggestion to place the arresters on or near the board. Experience has taught many that arresters should be at the entrance to the building or else outside altogether. As to the fuses, it is the writer's opinion that in no high tension work should reliance be placed solely on fuses. The many reasons for this opinion appeared in a previous article in this journal.*

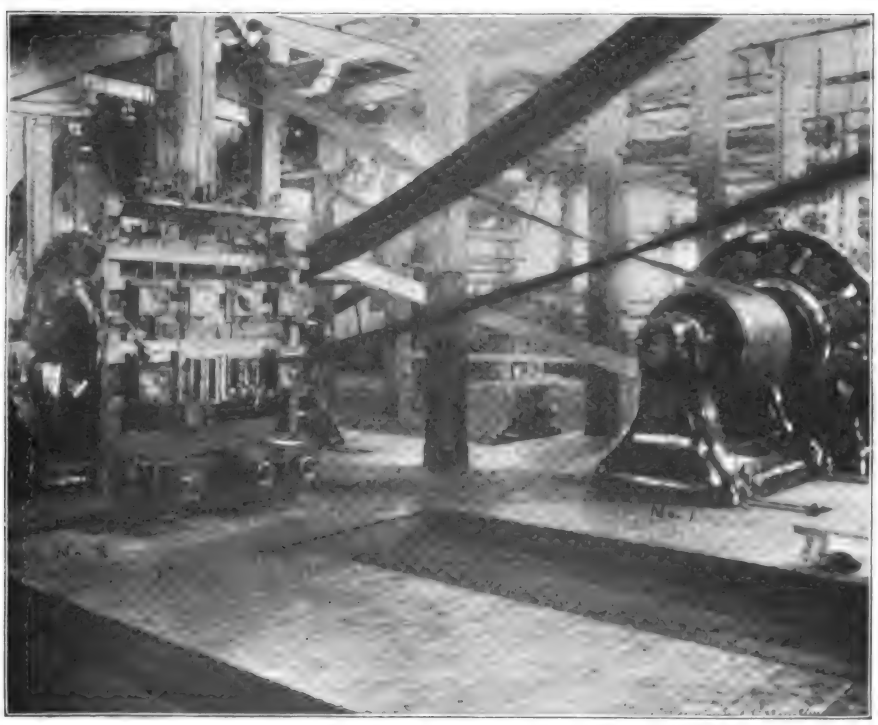


FIG. 9.—ORIGINAL SWITCH-BOARD FOR 250-KW, THREE-PHASE MOTORS.

In such cases as it is desired to use fuses, and when there is any question as to the certainty of their melting without arcing, they should be placed on edge on their sides in such manner that the arc will tend to lengthen as it rises, and to leave the terminals.

In many of the modern power stations where a number of generators are run, and it is desired to synchronize them, it will be found advantageous to possess some device by which the phase of all or any of the machines may be determined without going to the expense of transformers for each generator. In Fig. 7 is sketched a plan of a device which will not only do the work safely, but simply. There is no danger of a cross connection and possible short circuit, nor series of armatures raising the line voltage nor likelihood of a mistake in machine connections and subsequent disastrous paralleling. This device consists of two plug-boards placed, as in the case of an arc plug-board, one in front of and about 6 ins. distant from the other. There are two rows of contact holes in each and as many holes in each row as there are generators to be synchronized. The holes in each row in the back-board are connected together and each row is connected to one primary of a synchronizing transformer. The holes in the front board are entirely independent, each being connected to corresponding generator rings, one pair to each machine. The pairs lie in a vertical line. The contact consists of a plug with two prongs separated by a hard-rubber cross-bar and handle, and is so made that it will fit only such pairs of holes as lie in a line perpendicular to the base or rows. In very high voltage machine operation, it might be as well to construct between the boards, and connecting the front and rear holes, chutes or tubes of marble or

*August, 1897.

porcelain. The sketch shows how the transformers and lines are to be relatively connected to the board, and how the corresponding coincident, or instantaneous, potential values are taken into account.

The term "to synchronize," as used here, is possibly incorrect, but is used because it has apparently become a stock phrase in station men's vocabulary. It is taken in the sense of determining when synchronism is attained with the view of throwing generators in parallel, and often includes the latter operation.

The accompanying photographs will illustrate partially the progress which has been made in the evolution of suitable apparatus, and in improving the conditions of safety and convenience. The boards are all in one system. The double board in Fig. 8 was a temporary structure placed in the power house of the Baltic Power Company, at Baltic, Conn. It was believed at the time that this arrangement would answer every demand, but it soon became evident that for controlling heavy currents at high potential, specially constructed apparatus was necessary. The board in Fig. 4 shows the improvements. These switch-boards are not supposed to be examples of high art in the design of station equipment, but are shown, simply and solely to give any one interested an idea as to the position of instruments, switches, etc., which experience has taught to be the most convenient. Fig. 3 shows the back of this board, with transformers for lighting and synchronizing.

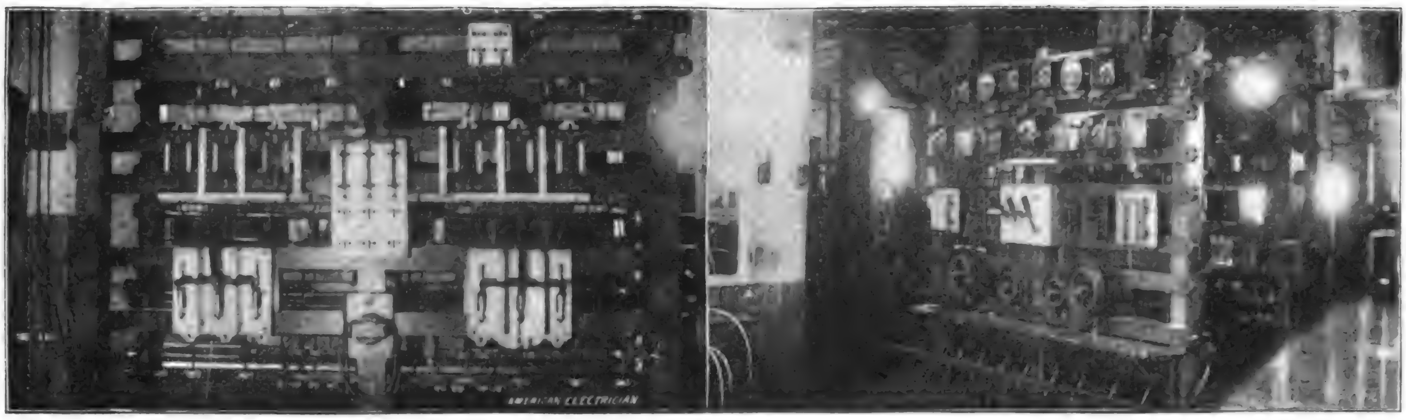


FIG. 10.—FRONT AND REAR OF NEW MOTOR SWITCH-BOARD.

FIG. 12.—SWITCH OPENED UNDER LOAD.

It was thought at first that perhaps, at the substation, it would be better to have the motor boards near each machine, and Fig. 9 shows such a board. This board soon exhibited the same quality of uncertainty as that in the Baltic station, and as there were two of them they were combined and constructed as in Fig. 10. The arrangement of this board is given in outline in Fig. 11.

Much of the special apparatus constructed for this system is now probably standard, so a detailed description of any of the parts will be superfluous. A good general idea of their construction and size may be obtained from the engravings. Fig. 12 represents a switch being opened under load, the arc, in this case, drawing out to nearly 12 ins. in length. The live side of the switch should be at the upper terminals, as such a vicious arc would be likely to strike across the blades, when they had opened beyond the marble guards. It is well in this connection to call attention to the fact that all high-potential parts of the board should be amply protected with marble or porcelain guards. Slate is allowable only on "single-pole" apparatus. It is too apt to contain metallic veins.

It will be noticed that all of the switches except the quick-break ones, are placed handle down. This is contrary to a very widely recognized custom, but is done with

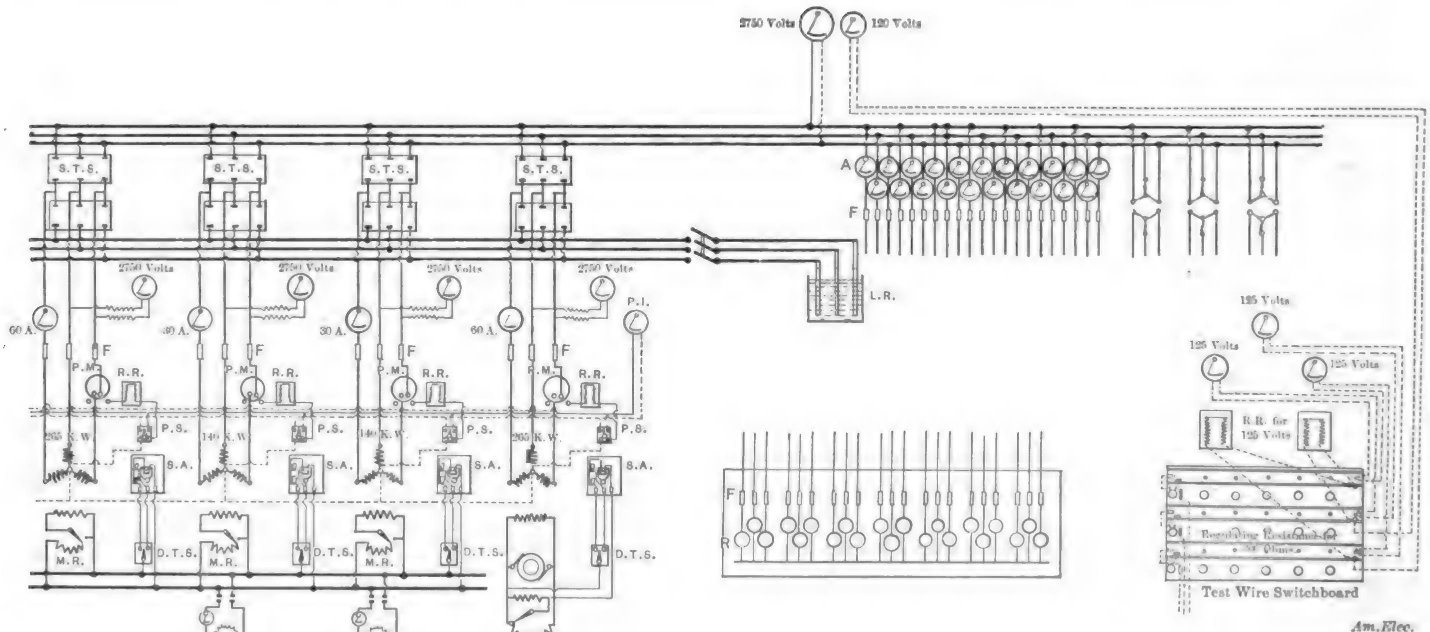


FIG. I.—DIAGRAM OF MAIN SWITCH-BOARD AT STRASSBURG STATION.

reason. The high-tension concealed clip switches are not supposed to be opened under load, so reversing them is not necessary on that account. In several instances when starting up during a thunder-storm, an arc struck across the terminals at the back of the switch, as soon as it was closed, which at that time was with the handle up. This arc, short-circuiting as it did a large machine at between 2500 or 3000 volts, developed a heat at the top of the switch which caused serious burns on the attendant's hand and arm. As this occurred several times, it was deemed just as well to turn this

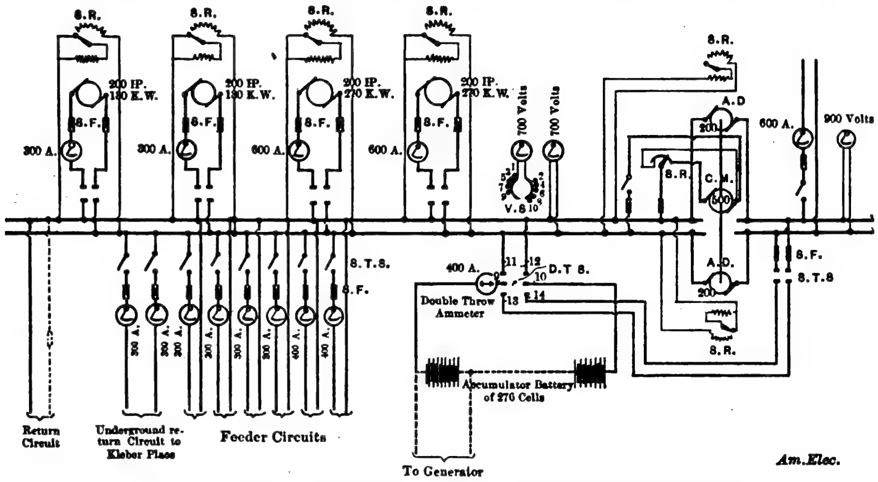


FIG. 2.—RAILWAY SWITCH-BOARD AT STRASSBURG STATION.

switch down. These trivial incidents are the ones that must place the most influence on board design and wiring, and it is on this account alone that so much room is taken with their recital.

THREE-PHASE SWITCH-BOARD OF THE STRASSBURG CENTRAL STATION.

The accompanying illustrations refer to the switch-boards in the three-phase central station at Strassburg, Germany, a description of which appeared in the September issue, the drawings arriving too late for use in the article.

As shown in the September issue, the switch-board is located on the gallery at one

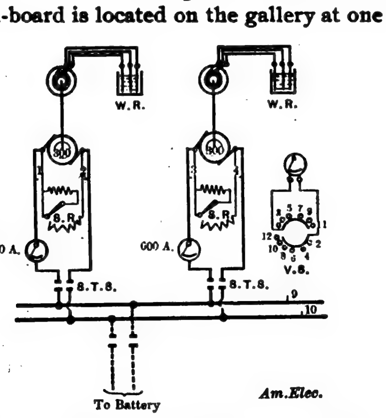


FIG. 3.—CONNECTIONS OF GENERATING SETS.

end of the generating room. Fig. 1 represents the main switch-board with four panels to the left not shown, as they are merely duplicates of the one to the extreme left of the illustration. At the right-hand corner of the same illustration is a diagrammatic representation of the test-wire switch-board, referred to in the September article.

Fig. 2 represents the railway switch-board, Fig. 3 shows the connections of the generating sets, mentioned in the September issue, and consisting of an engine having a three-phase machine on one end of its shaft and a continuous-current railway generator on the other end; the water rheostat shown in this illustration and those in Fig. 1 are for the purpose of throwing a load on the three-phase dynamos when switching them in parallel.

Following is an explanation of the abbreviations on the several illustrations:

A., ammeter; S. F., short-circuiting fuse for railway circuits; F., fuse; P. M., fuse-meter; P. I., phase indicator; S. R., starting resistance; R. R., regulating resistance; L. R., load resistance; S. A., signal apparatus, optical and acoustic; M. R., magnetic regulator; S. T. S., single-throw switch; S. R., shunt regulator; I. M., induction motor.; C. M., continuous-current motor; A. D., auxiliary dynamo; R., relay; V. S., voltmeter switch; D. T. S., double-throw switch; P. S., phase-meter switch; W. R., water resistance.

The testing switch-board carries three voltmeters for testing the secondary system of distribution, and two compensating resistances for the voltmeter on the generating board, besides an automatic fault-finding apparatus, referred to in the September article.

The switching in parallel of the three-phase dynamos is accomplished with the assistance of a voltmeter and phase indicator; when the machines are switched in parallel, the phase indicator forms an important aid in judging the equality of the load on the steam engine. On the main switch-board is an inductive resistance for each circuit, which is used in equalizing, if necessary, the inductances in the legs of the three-phase circuits.

Electrical Explosions that Didn't Occur.

An English local newspaper, in giving the particulars of a fire which occurred at the works of an electrical manufacturing company, said: "It was nothing short of providential that a number of dynamos stored in the building failed to explode, otherwise the damage to surrounding property would probably have been enormous." Some time ago another English newspaper, in describing a flood, referred to a great danger from explosion that was escaped through the water not entering a transformer sub-station!

ROTARY CONVERTERS AND THEIR USES.

BY DR. LOUIS BELL.

This brief article is not intended as a scientific discussion of the curious and interesting theory of rotary converters, but merely as a quite informal description of their properties and uses for the benefit of those who are unfamiliar with them.

The transmutation of alternating to continuous current and *vice versa* is sometimes necessary or convenient in modern practice, and until recently it has been regarded as very much of a nuisance. To speak in a general way, there are three methods of doing it which are in regular use, besides as many others in various stages of experimentation. First comes the obvious device of coupling together an alternator and an ordinary continuous-current generator, either by belting or directly, sometimes even combining the two with a common base and bearings.

The efficiency of such a combination is evidently the product of the efficiencies of the two. If each generator has an efficiency of 90 per cent., the net efficiency of the transmutation will be but 81 per cent. This means a rather serious loss, beside which the combination machine is rather cumbersome and costly. On the other hand, the alternating and continuous circuits are completely independent of each other, and each can be regulated with absolute indifference to the state of the other.

A second method sometimes employed consists of consolidating the two machines by winding an armature core with two distinct sets of coils, one for alternating current, the other for continuous current. The field, of course, is then common to both windings and the motor generator thus organized is simpler and cheaper, generally speaking, than a pair of machines. Inasmuch as the armature reactions in the motor and generator windings are opposed to each other, the two are in large measure free from the disturbances due to this cause and give a rather better output than they otherwise would. The armature windings of such a machine are, however, complicated and neither can conveniently be of very high voltage, owing to mutual proximity. As the field is common to both, it cannot be varied without affecting both circuits, which is a manifest disadvantage. The efficiency is perhaps a trifle higher than with two separate machines, but still leaves much to be desired.

At present both these devices have been largely superseded by the rotary converter, which has as its fundamental idea the recognition of the generally overlooked fact that every common dynamo of necessity generates alternating current in its armature and yields continuous current only in virtue of commutation. In fact the sole function of the commutator is to straighten out these alternating currents.

Suppose now, we take advantage of this fact starting with the simple two-pole ring winding shown in Fig. 1. Let us attach collecting rings, *C C*, to a pair of diametrically opposite points in this winding and lift the ordinary brushes, *B B*. We now have a

simple alternating armature with the two values in multiple as they often are in commercial machines. The only unusual thing about it is the complete distribution of the coils, and when put in action it would behave like any other alternator, generating current in precisely the same manner as before, but delivering it in its original form at $C\,C$, instead of commutating it at $B\,B$. Now if the brushes, $B\,B$, are lowered and connected, part of the current will be com-

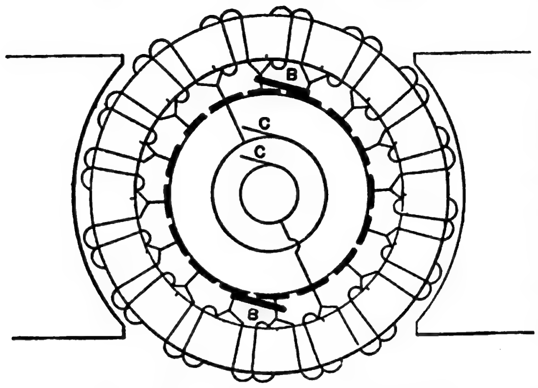


FIG. 1.—SIMPLE TWO-POLE WINDING.

mutated in the ordinary way and delivered to the new circuit, while as respects $C\,C$, the machine is still an alternator. This forms the double-ended generator now occasionally used.

Lifting $C\,C$, the machine simply resumes its ordinary function as a continuous-current generator.

Now, instead of driving the armature by its pulley, suppose that we slip off the belt, send into the rings, $C\,C$, alternating current of the same frequency as that previously generated in the machine, and start it as an alternating motor. When at synchronous speed the current will circulate in the armature coils much as if it were generated in them and will be commuted at the commutator, supplying the necessary field excitation. Moreover, current for other purposes can be drawn from the commutator, for with the armature current circulating as if it were generated there the process of commutation goes on exactly as it did when the machine was used as a continuous-current dynamo and while a small portion of the energy flowing against the counter E. M. F. set up by the field is spent in keeping up the armature rotation the rest flowing as if urged by this E. M. F. can be taken from the brushes as continuous current. There is, however, this difference—when the machine is thus used as a rotary converter there are moments when the rings, $C\,C$, are connected directly to the segments of the commutator under the brushes, $B\,B$, and the average path of the current is thus somewhat shortened.

This then is the fundamental idea of the rotary converter, to feed into a revolving armature the same current which it would produce if running as a generator and to let this current be commutated as usual. It is as if the machine neither knew nor cared whether the current were actually generated in its armature or the same current were poured into it through collecting rings.

In every-day practice single-phase rotary converters like Fig. 1 are seldom used. They will not start themselves as alternating motors nor do they give a very good output. Ordinarily the rotary converters are wound for two or three phases. Fig. 2 shows a two-phase form provided with a pulley for use as a double-ended generator if necessary, and Fig. 3 shows in diagram the way in which the three-phase form is connected. The winding is merely tapped at three points 120 degs. apart, while the two-phase converter is usually connected at four points 90 degs. apart, and has four collecting rings like Fig. 2. Note that in these forms the average path of current through the armature from rings to brushes is quite short and consequently the C^2R, loss in the armature is small and the armature reaction is also small. The efficiency of such machines is consequently high and a large output can be obtained from them, larger than from the same machines used as continuous-current generators or connected as single-phase rotary converters like Fig. 1.

In point of fact these two- and three-phase machines give with at least as great efficiency very considerably better output as converters than they would give as generators. Theoretically the greater the number of points at which the armature is tapped the better the efficiency, so that four taps should be better than three; six, as in a three-phase connection with six leads better than four, and so on. Practically the more complicated forms are seldom used and the difference between them is of less moment, so far as increased efficiency or output is concerned, than the difference between any one of them and an ordinary generator.

There are many points of interest about these machines—too many for an article so brief as this. They are self-starting, coming up to nearly synchronous speed as induction motors in virtue of the secondary current induced in the pole-pieces, taking, however, a large current, and are then readily synchronized.

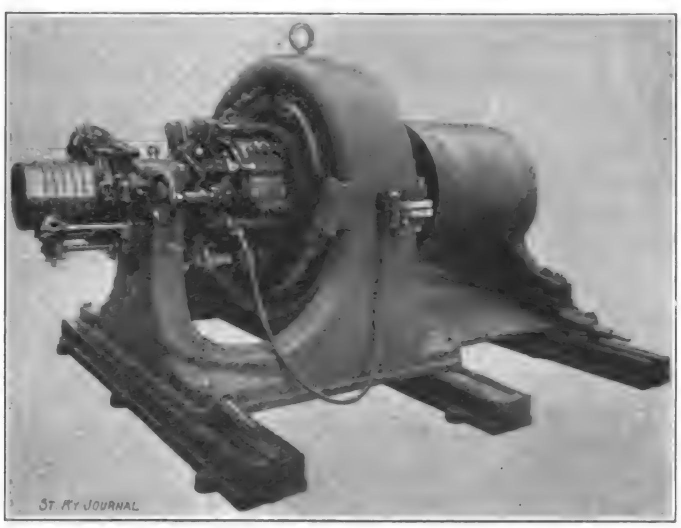


FIG. 2.—TWO-PHASE ROTARY CONVERTER.

As will be readily seen from Fig. 1, the current delivered from the brushes is of a polarity that depends on the direction of the current under them when the switch is closed upon them. Once in synchronous running, commutation is perfectly regular, but either brush may catch a positive current at the moment of starting. Hence special precautions have to be taken to get the proper polarity in starting—generally a few trial touches through a lamp or the like, and then when the polarity proves to be right the machine is put into regular service. Rotary converters run in parallel admirably, on the continuous side, the alternating side or both sides, and behave in general like very excellent generators.

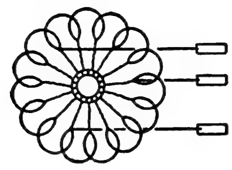


FIG. 3.—DIAGRAM OF THREE-PHASE ROTARY CONVERTER.

The voltage of the alternating and continuous circuits is, of course, different, the former being uniformly the lower, by amounts varying with the armature connections. In two- and three-phase converters the alternating voltage as measured is generally between .6 and .7 of the continuous voltage subject to some modification due to the field strength. Change in this affects, of course, the voltage of both circuits, but in a very complicated manner. From this and from the general interdependence of the two circuits it is no easy matter to hold the continuous-current voltage accurately steady under changes of load. For railway purposes, however, the apparatus takes care of itself very well indeed, and it is for this work that the rotary converter is best fitted and most likely to be used.

In general the rotary converter furnishes the most efficient and useful method of getting continuous from alternating currents. No simpler process has yet been reduced to practice on any considerable scale. A few attempts have been made at simple rectification by a revolving commutator driven by a synchronous motor. These have succeeded fairly well on a small scale, but it is extremely difficult to avoid destructive sparking. If the current and E. M. F. are not in phase, obviously there can be no moment when both the current and the E. M. F. between commutator segments are simultaneously zero; hence the conditions for sparking are always present. With small currents as for arc circuits fairly good results have been obtained. In addition there has been an exceedingly ingenious method devised for imitating the ordinary conditions of commutation without a revolving armature, a method at present too wholly experimental for consideration here; and finally, there has been tried a very curious scheme for sifting out the currents of one polarity by means of electrolytic cells. It is as if one were to pass an alternating current through an ordinary

galvanic battery—impulses in one direction would be opposed by the battery E. M. F. and if this were high enough they would be completely suppressed. This plan involves electro-chemical and other difficulties which have so far kept it in the experimental stage.

Given the rotary converter, the next question is when and how can it be advantageously employed? Just now it seems best suited to electric railways and to certain electrolytic purposes. It will doubtless be not infrequently used for lighting, although such use involves some rather intricate problems in regulation.

In railway service it most often comes into play in the following manner: A long line is under construction and it seems advisable to use standard 500-volt apparatus on the cars. Transmission of the requisite power at 500 volts would demand an enormous outlay for copper. The question at once arises whether it is better to generate the power at a single station and transmit it to rotary converter stations along the line or to establish separate generating stations. The question is really one of dollars and cents, for both plans are easy of execution. In the one case the cost of power is increased by the loss in transmission and reconversion, in the other by the difference between one large station and several smaller ones. Fortunately we can form a pretty clear idea of the losses in the former case. In the line, transformers and rotary converter stations the losses under ordinary conditions of load are likely to rise to not far from 25 per cent. To this loss of power we must add the interest and depreciation on the transmission system and the attendance at the stations.

Unless power can be generated in a single station for from two-thirds to three-fourths of the cost of generation in separate stations the latter are likely to prove the more advantageous. Hence, if the aggregate amount of power is several thousand kilowatts the separate stations will usually be large enough to be run within this variation of economy and so render a transmission needless. If only a few hundred kilowatts are involved the balance is likely to be the other way, and between these limits lies a debatable ground which requires careful investigation in each particular case.

It must be remembered, however, that sometimes a transmission system gives access to cheap water power or to a specially favorable location for a power station.

On the other hand, if one is obliged to incur a loss of 25 per cent. in transmission, the intelligent use of a booster will sometimes enable the power to be delivered at a distant point without the complication of a transmission plant.

To get a clear idea of the way in which these conditions appear in practice, let us assume the following example of feeder design: Suppose it is necessary to put 500 amperes upon the distribution system of a railway, 75,000 ft. from the base of operations where the principal station is located. The initial voltage is 575, while the pressure at the end of the feeding line must be 500 volts.

If we attempt to feed directly the call for copper is serious. With ordinarily good track conditions we may assume the following formula for the total weight of copper:

$$W = \frac{42\, C L^2{}_m}{E}$$

where L_m is the length of feeder in thousands of feet, C the current and E the drop. In our present case

$$W = \frac{42 \times 500 \times (75)^2}{75} = 1{,}575{,}000 \text{ lbs.},$$

costing, say, $236,000. This is quite out of the question, so let us face a loss of 25 per cent. in boosting for transmission. If current is delivered at 500 volts with this loss the full initial voltage at the booster would be 666, and the copper required would be

$$W = \frac{42 \times 500 \times (75)^2}{166} = 714{,}000 \text{ lbs.},$$

costing about $107,000. To this must be added the cost of a booster for 500 amperes and about 100 volts and its motive power.

If one resorts to a transmission and rotary converter, one must supply a converter for 250 KW with its complete equipment and house, the transmission line and raising and reducing transformers—not over $25,000 all told. The substation, of course, requires attention, and the transmission system has a larger depreciation than plain feeder copper. But if the 500-ampere output is a pretty steady demand, the rotary converter station certainly has the best of it. On the other hand, if the demand is generally far below 500 amperes the booster system could probably be worked at 25 per cent. average loss with far greater drop than above, bringing the copper down to $50,000, at which cost it would probably have the advantage.

Similarly, the economy of separate stations depends on the conditions of load. If 500 amperes is pretty steadily demanded and the main station is of about the same size, independent stations would probably be cheaper than transmission. If the main station is already large and the output at the distant point quite irregular, transmission will generally pay.

Nice balancing of costs is always needed in deciding between separate stations, boosting, and substations with rotary converters. These last are at their best on lines 20 miles or more in length where the aggregate power is moderate, and the cost of producing power at various points is by no means uniform.

COAL AND ASH HANDLING APPARATUS.

SOME months ago an article in these columns directed attention to the advances made in recent years in mechanical stoking, and a description was included of all the principal types of automatic stokers and shaking grate-bars on the market. Within a still more recent period coal and ash-handling apparatus have come to the front, and in order to place our readers in touch with this further important development in boiler room economy, we print below descriptions of the several systems of this apparatus that have entered into general use.

Some years ago it was an exception to see coal- and ash-handling machinery in a central or power station. At the present time, however, almost all large modern electrical generating stations are being equipped with such machinery, and an engineer would be considered behind the times if in a new design of a station of even medium size, he did not provide for the mechanical handling of coal and ashes.

Fig. 1 represents the arrangement of the coal-handling plant put in the station of the Edison Electrical Illuminating Company, at Boston, Mass., by the C. W. Hunt Company. The coal is raised from boats brought alongside the station, and dumped into a hopper which feeds the conveyor. The coal may then be delivered into the storage shed or fed direct to the boiler coal tanks. The ashes from the boilers are carried to a bin, shown to the right of the illustration, into which they are dumped and thence loaded into scows for removal.

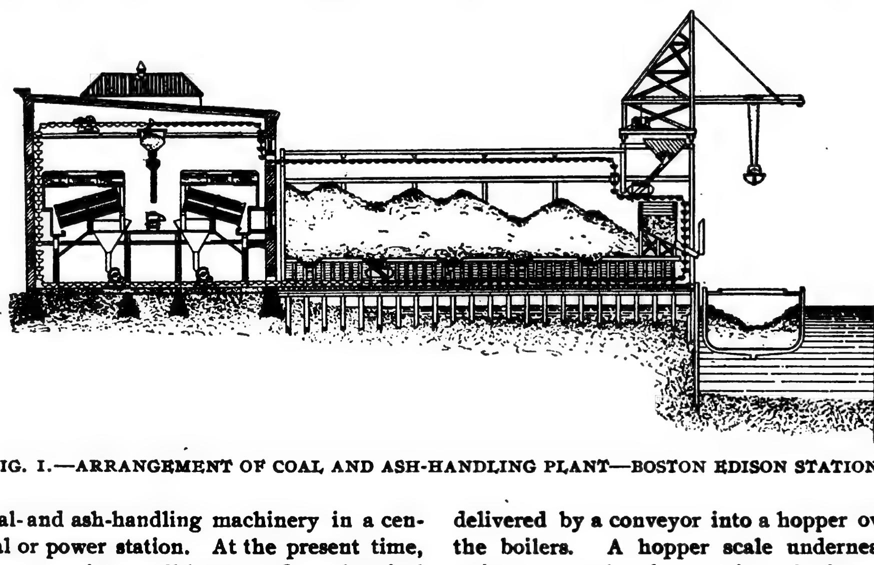


FIG. 1.—ARRANGEMENT OF COAL AND ASH-HANDLING PLANT—BOSTON EDISON STATION.

Fig. 2 shows the arrangement of the Hunt conveyor in one of the stations of the Edison Electrical Illuminating Company, at Brooklyn, N. Y. The coal is taken in carts and delivered by a conveyor into a hopper over the boilers. A hopper scale underneath weighs the coal and spouts it to the front of the boiler. The ashes are taken automatically from the ash chute to a separate hopper, from which they are spouted through a chute in the side of the building to wagons for removal.

The peculiar features of the Hunt conveyor system are that the whole machine is carried on wheels; change of direction is accomplished by running round curves instead of

sprocket wheels; the chain is driven by pawls instead of by sprocket wheels, and the conveyor is practically noiseless in operation. It is moved very slowly, the capacity being dependent upon the size of the buckets and not the speed of the chain, and the buckets can be made large enough to carry the largest lumps of bituminous coal. Finally, material is carried to its destination

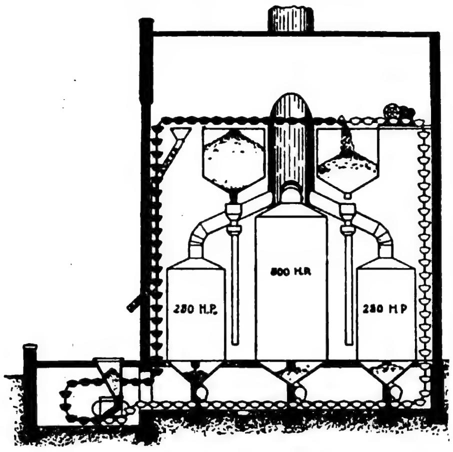


FIG. 2.—CONVEYOR PLANT IN BROOKLYN EDISON TTATION.

without being disturbed or shaken on the way.

The conveyor, chain and bucket are shown in Fig. 3. The chain is composed of of heavy wrought-iron links, and on axles attached to the links are flanged wheels, which run on a track similar to that of an ordinary railway.

and as the buckets dump in succession, the fuel will thus be fairly well mixed when it arrives at its destination.

The Hunt conveyor is driven by pawls engaging with pins on the chain, as shown in Fig. 4. This method is claimed to give a motion that is evener and steadier than that obtained by sprocket wheels, and also permits the power to be applied to the chain at a point where it is most convenient. Two pawls are always engaged in shoving the chain along. The ordinary size chain with

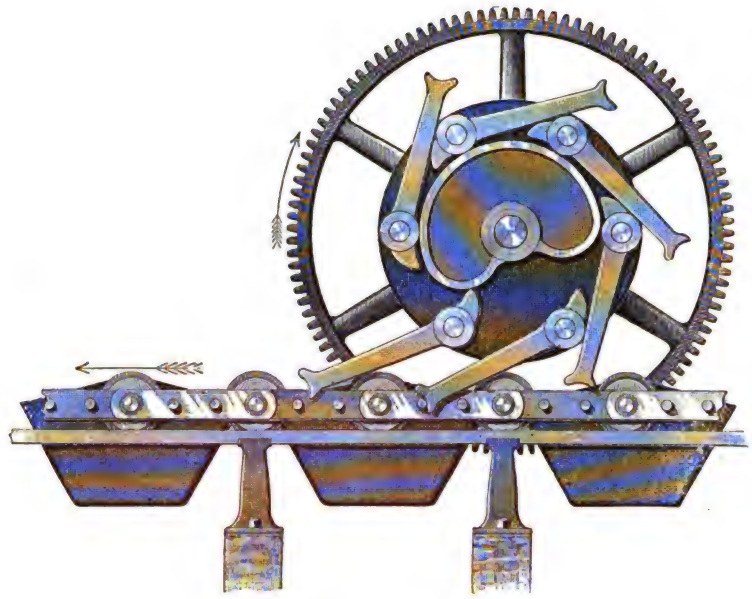


FIG. 4.—HUNT DRIVING MECHANISM.

and this conveyor deals with that material in the above mentioned establishment.

The conveyor runs in a pit 3 ft. wide and 3 ft. deep a distance of 80 ft. along the front of the boilers and to the side of the building; it then extends 18 ft. further at an angle of 30 degs., to a height of about 9 ft. so as to deliver the ashes to a car, wagon or other conveyance.

The principal feature of this conveyor is the trough (Fig. 6). This consists of two 4 in. channel bars and a plate ¼ in. thick, forming the bottom. Across the top of the flight, a 1 in. angle-bar is riveted, and extending over the top of the channels, rests on them, thus carrying the flight ⅛ in. above the bottom of the trough. By this means the friction in the trough is reduced to a minimum, and only the weight of the ashes tends to wear out the plate forming the bottom of the trough. This plate would therefore last

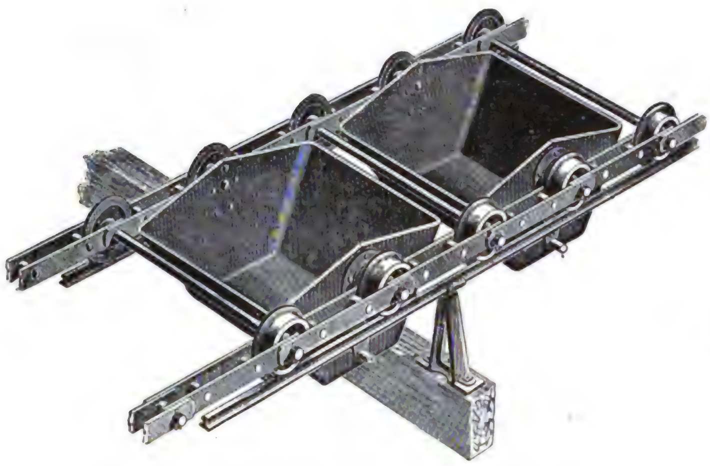


FIG. 3.—HUNT CONVEYOR, CHAIN AND BUCKETS.

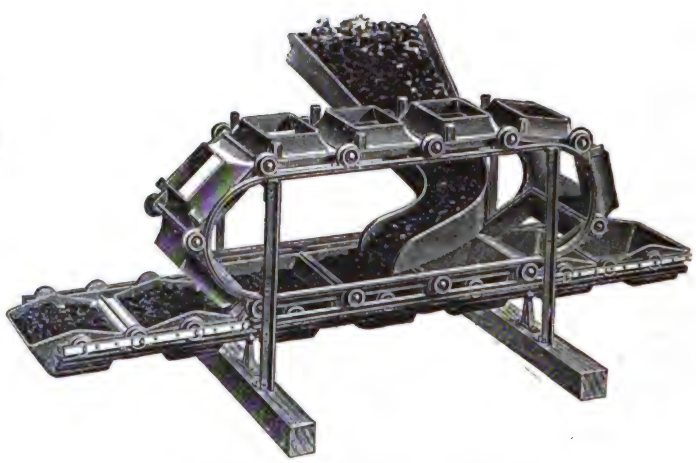


FIG. 5.—METHOD OF FILLING BUCKETS.

As the conveyor is an endless chain, it is always in equilibrium when not carrying materials and the force to move it is only that required to overcome the friction at the wheels of the weight. The buckets hang upright in all positions of the chain, which consequently can be run in any direction that may be necessary.

Fig. 5 shows the method adopted for filling the buckets. There are two forms of this arrangement, one being a measuring filler and the other a spout filler, the former delivering to each passing bucket the proper quantity of material. The spout filler, shown in Fig. 5, is a continuous feed, material running into the buckets as each one passes; motion is given to the filler chain by flanges of the spouts projecting into the conveyor buckets. Several fillers can be used in succession for measuring and mixing fuels, each putting in the buckets a definite quantity,

buckets carrying 2 cu. ft. of material, runs at a speed of fifteen buckets per minute or 40 tons of coal per hour, which capacity, however, can be temporarily increased to twenty-five buckets per minute, giving a capacity of about 80 tons of coal per hour.

as long as if it were on an incline, and the ashes merely sliding down. The power required to drive the conveyor is less than 1 HP. Fig. 9 shows the driving wheel.

As elevators and conveyors are used principally to handle gritty materials, and are

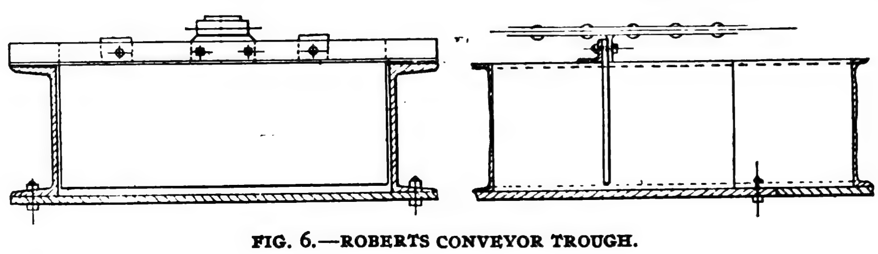


FIG. 6.—ROBERTS CONVEYOR TROUGH.

Figs. 6 to 9 show the details of an all-steel conveyor recently installed by the Roberts Manufacturing Company, in the Standard Bleachery, Carlton Hill, N. J. The most refractory material to handle is probably ashes,

located in such relatively inaccessable places, that lubrication is difficult if not entirely impossible, the Roberts Company advocates the use of most durable material obtainable, which is unquestionably steel.

There was a time when the manufacture of steel was not far enough advanced to permit of its general use, owing to brittleness and

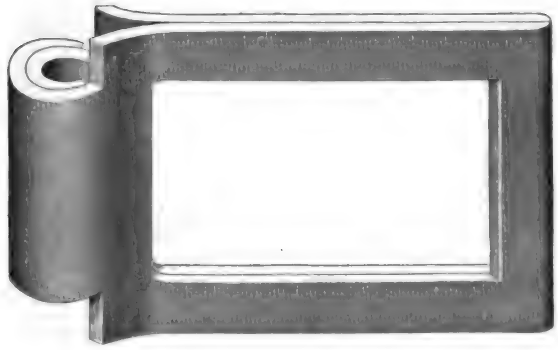


FIG. 7.—ROBERTS CONVEYOR LINK.

lack of uniformity. That time has passed, however, and open-hearth steel as usually produced will admit of bending, flanging and shaping, cold, that was never dreamed of in the use of the best refined wrought-iron, hot. The Carnegie Steel Company produces over 1000 tons per day of steel of this quality at the Homestead Works, near Pittsburgh, Pa.

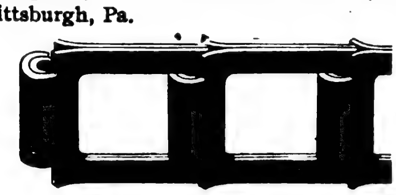


FIG. 8.—ROBERTS CONVEYOR CHAIN.

The chain (Figs. 7 and 8) of the Roberts Manufacturing Company is made of this kind of steel, which permits the links to be pressed cold at one stroke of the die. Elevator buckets, bolts, shafting and the bottoms of boots are steel, and in some cases the sprocket wheels are made of

FIG. 9.—ROBERTS CHAIN WHEEL.

steel castings. The conveyor flights and the trough are also made of steel, no other material thus entering into the construction.

Fig. 13 shows a complete system of elevating and conveying machinery for both coal and ashes, installed in the Beach Street power house of the Union Traction Company, Philadelphia, by the Link Belt Engineering Company.

The coal is received in a large hopper

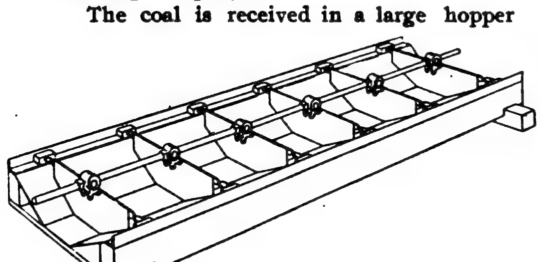


FIG. 10.—MONOBAR CONVEYOR.

immediately outside of the building, and is carried up by a continuous strand of gravity-discharge steel buckets, to the point where it is received in the conveyor, which runs down the entire length of the boiler house over the suspended steel coal hopper. The conveyor running over this hopper

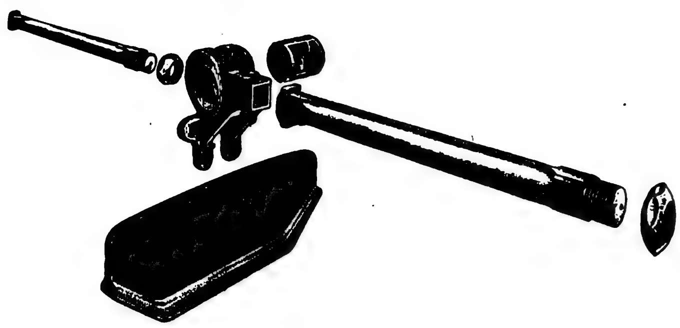


FIG. 11.—MONOBAR CHAIN.

is of the noiseless suspended type, illustrated herewith in detail. The steel hopper is furnished with distributing chutes, some of which discharge immediately in front of the boilers, and others lead back to the special storage room in front of the boilers.

A complete system of screw conveyors,

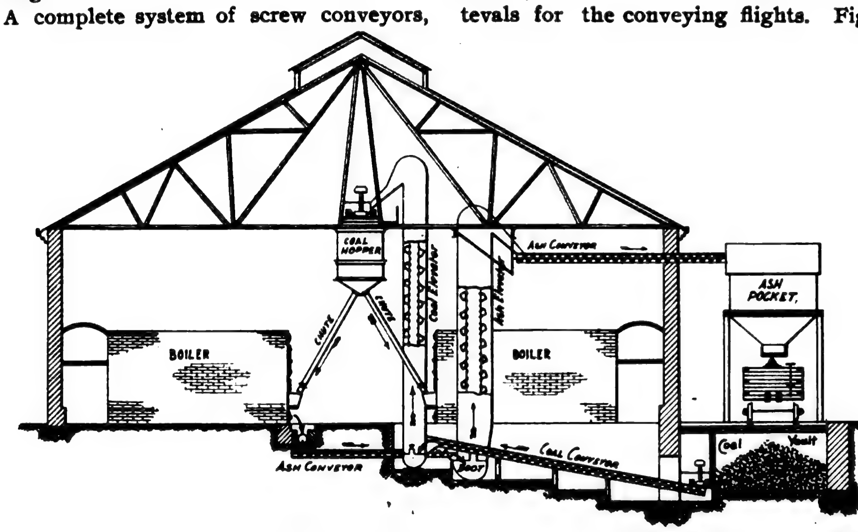


FIG. 12.—ARRANGEMENT OF POWER HOUSE COAL AND ASH-HANDLING PLANT.

especially designed for the work, take the ashes from immediately in front of the boilers and bring them to the elevator, where they are taken up and placed in an

FIG. 13.—BOILER ROOM, BEACH STREET, PHILADELPHIA, POWER HOUSE.

ash hopper fitted with a spout for dumping through the wall to the carts outside.

The coal-handling machinery is connected together and driven by a friction clutch, so that the whole machinery can be thrown into operation by the shifting of one lever; in case of a serious obstruction taking place in the machinery, the friction clutch would slip, thus avoiding a serious break-down.

The chain used in the link-belt conveyor is known as the "Monabar chain," shown in Fig. 10, which consists of a series of bolts flexibly connected with attachment at intevals for the conveying flights. Fig. 11 shows this chain with the flights ready for assembling. The average length of the bolts is 18 ins. × 1 in. in diameter. The working strain is that of the high-grade wrought-iron bolt of the diameter employed. Where a long-pitched chain is used, unless the wheels are of a correspondingly large

diameter, a pulsating motion will be imparted to the chain. In order to counteract this, the Link-Belt Engineering Company has invented and patented the equalizing gears shown in Fig. 14, which counteract the pulsating motion imparted by the driving wheels. These gears impart a pulsating motion to the driving sprocket wheel exactly counteracting the variations of chain speed above explained, and insuring a uniform motion. Heretofore a specially built engine has been used to overcome this difficulty.

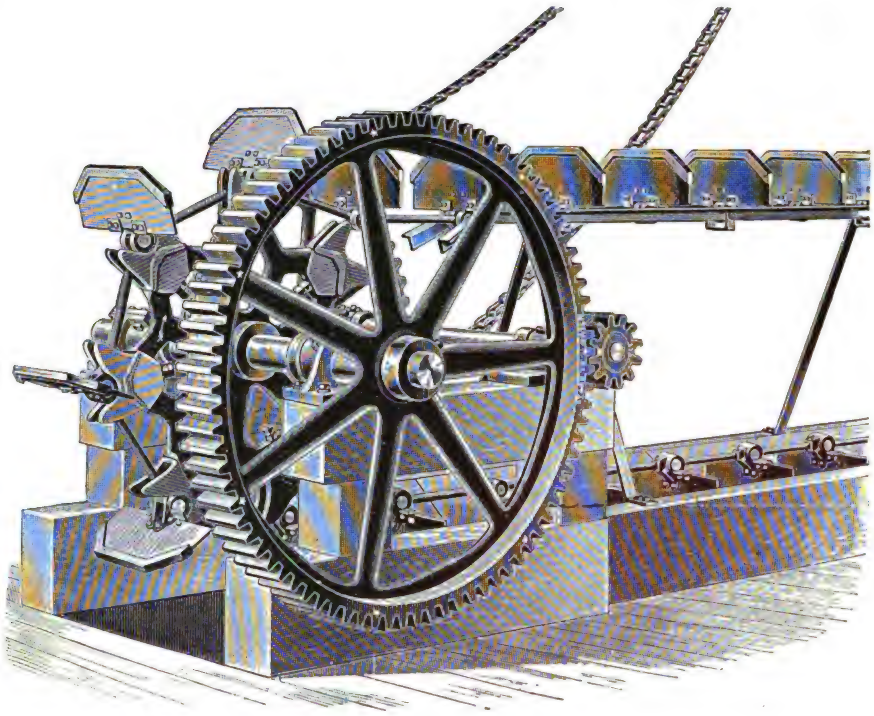


FIG. 14.—LINK-BELT DRIVING GEAR.

Fig. 12 gives a sectional view of another large electric power house in Philadelphia, where the coal from the steam cars is delivered in a vault running for some distance under the tracks, and is handled by a coal conveyor constructed of "Monobar chain," with equalizing gears and noiseless, suspended flights. Coal flows into this conveyor from the vault at any point along its entire length, and is carried to an incline screw-conveyor, which in turn delivers it to an elevator which carries it to another monobar conveyor running over a suspended coal-hopper the entire length of the power room. This coal-hopper is fitted with chutes feeding to the mechanical stokers of the boilers at each side of the room.

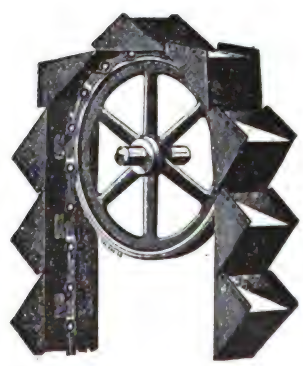


FIG. 15.—JEFFREY ELEVATOR.

The handling of the ashes in this plant is done by means of special cast-iron screw-conveyor running immediately in front of each boiler, and placed a sufficient distance underneath the floor. The ashes pass through a grating to the screw-conveyors underneath, and are by them carried to the ash-elevator which, in connection with another screw-conveyor, places them in the ash-pocket immediately over the railway tracks. When the fireman is ready to take the ashes away, he throws in the clutch controlling the ash-handling machinery, and then draws his ashes into the screw-conveyor, which delivers them without further handling, into the ash-pocket, where they are ready for delivery to the cars.

Fig. 17 shows the interior of a 4000-HP boiler room of one of the largest street railway systems in the country, which has been equipped throughout with modern labor-saving appliances for handling coal and ashes, by the Jeffrey Manufacturing Company, of Columbus, O. The main storage bin is outside the boiler house and holds 300 tons of coal, which is delivered entirely by wagons. If this coal happens to be lump, it is run through a toothed crusher and reduced to nut size. From the crusher it is elevated by a continuous bucket elevator built with wrought steel buckets and chain, to a sufficient height to spout to a conveyor running over the storage bins, the whole length distributing the coal to the bins.

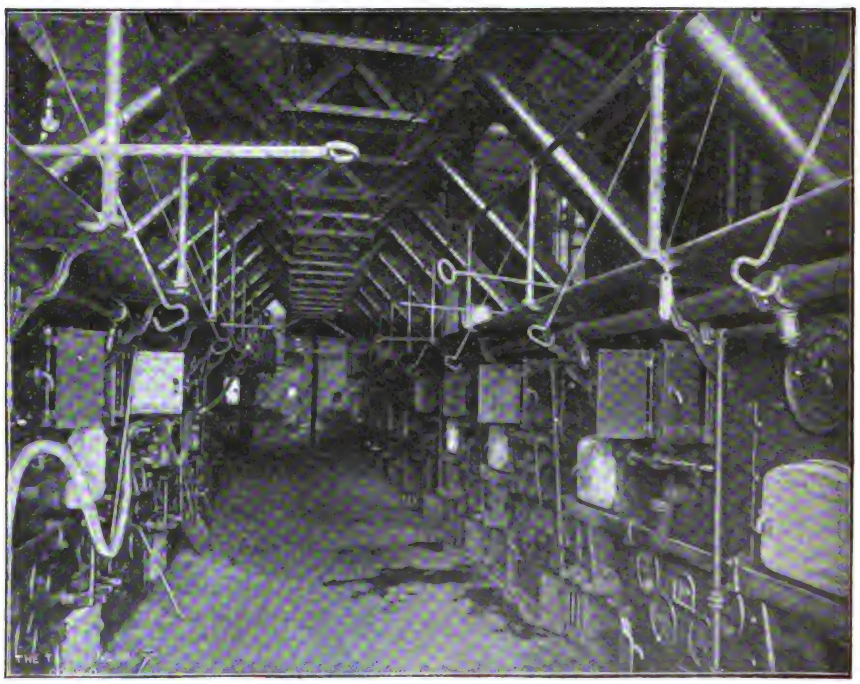


FIG. 17.—BOILER ROOM OF COLUMBUS, (O.), POWER HOUSE.

One of the principles insisted upon by the Jeffrey Company in the storing and handling of bituminous slack in order to prevent spontaneous combustion, is to daily turn it over on itself. For this reason the bottom of the storage bin is hoppered at 45 degs. and lined with steel. Each day the supply of coal is taken from this storage bin, care being exercised to move every particle in it. This is accomplished by opening each gate in turn, these gates being placed in the bottom of the bin every 8 ft. As each gate is opened, the machinery being in operation, the coal flows into the lower trough of the bin conveyor and is conveyed to the elevator used to put it into the bin, which in turn delivers it to a cross conveyor to be delivered to a longitudinal conveyor over the boiler house coal bunkers. Two hours suffice to fill the bunker for a twenty-four hours run.

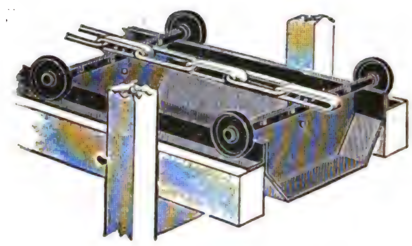


FIG. 16.—JEFFREY CONVEYOR.

The type of conveyor used throughout the plant is the noiseless drop flight. Being made wholly of wrought steel, it is capable of the most effective work, employing a min-

imum of power for its operation. In addition to the coal-handling system, the plant is equipped with a system of ash-handling machinery located in the basement, consisting of two 60-ft. cast-iron spiral conveyors and special elevator. The ashes are wet down and dumped from the hoppers located under each battery of boilers into one of the 60-ft. conveyors, which passes them along to a spiral conveyor at right angles, which delivers them to the elevator. When elevated, they are spouted into a tank placed outside the building, whence they are loaded into cars and carried away. A 50-HP horizontal engine located in the basement furnishes the power for the entire system, each portion of which is provided with friction clutches for its perfect control.

Fig. 18 gives a view of the conveyor installed by the Jeffrey Company in the Twelfth Street station of the New York Edison Illuminating Company. Coal is dumped from wagons into a weighing hopper. After being weighed it is conveyed by means of a screw-conveyor to an elevating conveyor, which is shown through the doorway on the left of the illustration; the coal is then discharged into a receiving chute and is finally conveyed to the openings of boiler storage bins, as shown in the engraving.

FIG. 18.—JEFFREY CONVEYOR IN TWELFTH STREET, NEW YORK EDISON STATION.

The type of elevator used, together with a traction wheel, is shown in Fig. 15. The motion of the wheel being clockwise, it will be seen that the side of each bucket forms a discharge spout, thereby preventing the spilling of any material down the legs. The buckets cover the chains completely, thus protecting them from cutting. An advantage claimed for this arrangement is that the fuel can be spouted or feed direct. The weight of the chain and buckets of the wheel produce sufficient traction to raise the load.

Fig. 16 shows the type of scraper-conveyor used, together with the roller attachment and chain. One of the advantages claimed for this type is that it is practically noiseless. In Fig. 18 both the elevating and horizontal conveyor have a double chain instead of a single one, as shown in the detail figure. Fig. 19 shows a type of cast-iron spiral conveyor used for moving ashes; when used to handle coal the spiral is made of steel.

The coal-handling system of John A. Mead & Co. is shown in Figs. 19, 20, 22, and 23.

Figs. 22 and 23 illustrate the arrangement of coal conveyors in the new power station of the Chicago City Railway. Cars direct from the mines run over the hopper shown in Fig. 22, into which they discharge their load. The coal is taken from this receiving hopper and carried over the tops of the boilers, where it is dumped into storage tanks, as shown, a movable dump-block fixing the point where the coal is to be discharged. The same conveyor receives the ashes from beneath the boiler. *B* is a movable ash-hopper into which the ashes, after being wet down, are raked; the ashes are then dropped into the buckets of the conveyor and carried to the ash-hopper, shown to the right of the figure, whence they discharge into a railroad car.

Fig. 23 gives a transverse view of the conveyor tracks; the conveyor will be seen located over the coal tanks, the discharge chute of the latter into the fire-room being also shown. The lower part of the engraving shows the ash-chute, beneath which is the tunnel for the conveyor.

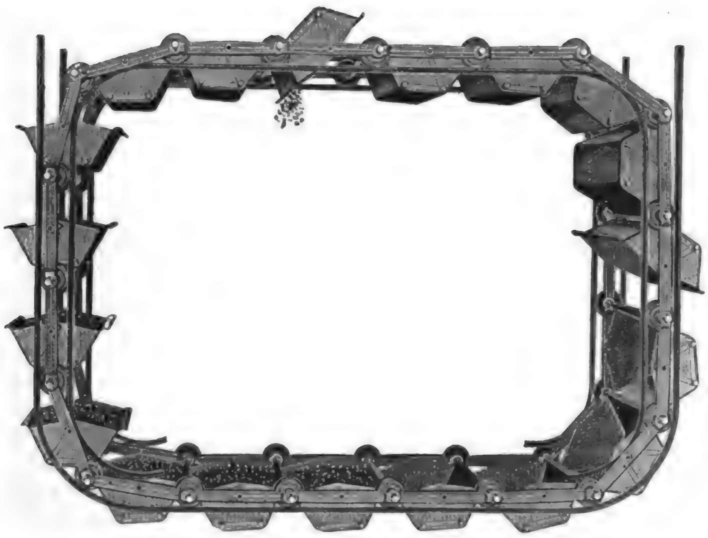


FIG. 19.—MEAD CONVEYOR.

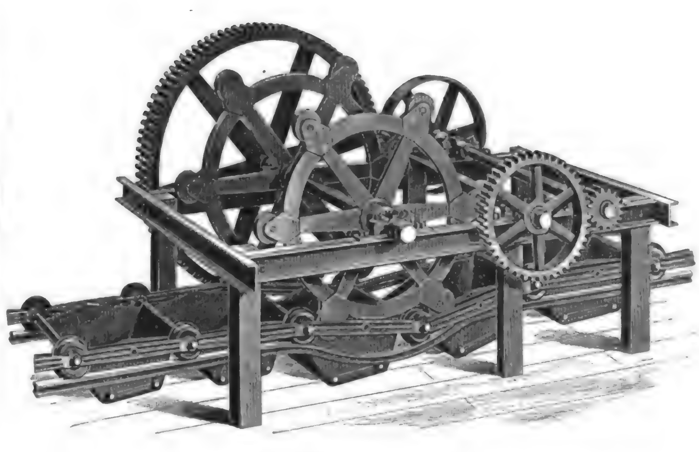


FIG. 20.—MEAD DRIVING MECHANISM.

Fig. 19 illustrates in detail the McCaslin overlapping, gravity, bucket conveyor, installed by the Mead Company in the above plant. The conveyor is composed of an endless series of chain links and cross shafts mounted on track wheels, the conveyor buckets being pivotally mounted in the

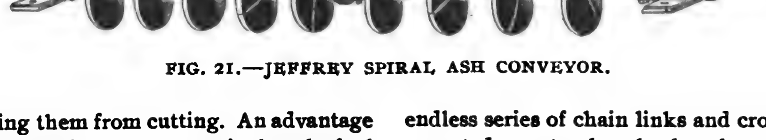


FIG. 21.—JEFFREY SPIRAL ASH CONVEYOR.

chain. The conveyor is supported on and guided by the system of tracks through all the various changes of angle or direction in which it moves. The conveyor buckets, when on a horizontal track, overlap in such a manner as to form a continuous receptacle, and in passing from the lower to a vertical or inclined track they are maintained in a normal or upright position by gravity. The overlapping flanges will be seen in the engraving, one of which laps under and the other over adjacent buckets. This overlapping prevents the spilling of the fuel, which is delivered into the conveyor at any desired point along the horizontal track through an ordinary chute, no filler being required.

The driving mechanism is shown in Fig. 20, and consists of two hexagon-shaped spider wheels having rollers in the outer ends of their arms, which bear against the track wheels of the conveyor, the track at the driving point being concentric with the centers of the driving wheels. There being no sliding or lost motion between the driving spider-wheels and the conveyor chains, there is consequently a minimum of wear. The motion imparted to the conveyor by this arrangement is claimed to be remarkably even and steady, and any elongation in the centers of the chain links is automatically compensated for by the contact between the driver and chain. Every working part of this conveyor has a bearing that is lubricated, and the driving mechanism may be located at any point most convenient to the engine or power, as it may be placed at any point on the horizontal or vertical track, or in the curve of the track.

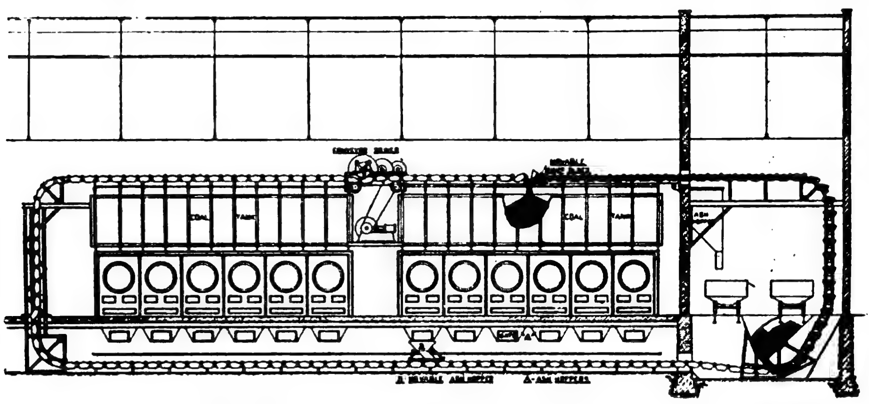


FIG. 22.—ARRANGEMENT OF COAL-HANDLING, PLANT, CHICAGO CITY RAILWAY POWER HOUSE.

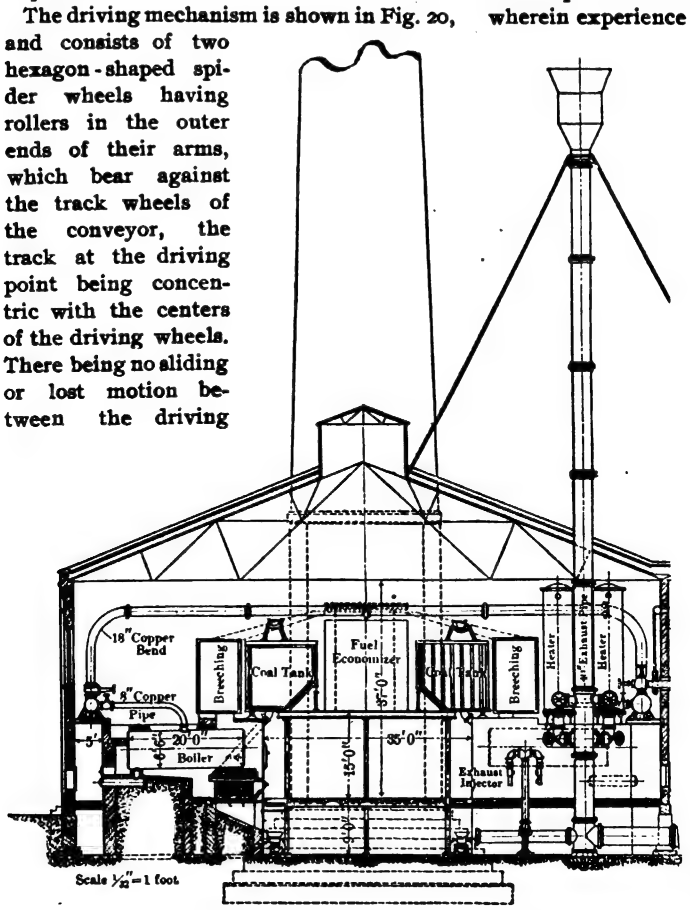


FIG. 23.—BOILER ROOM, CHICAGO CITY RAILWAY POWER HOUSE.

220-VOLT LAMPS.

BY ALFRED H. GIBBINGS, ASSOC. I. E. E.

Electrical Engineer to the Corporation of Bradford, England.

I have read with much interest Prof. G. D. Shepardson's paper on "220-Volt Lamps," * and the few comments which I am able to make may indicate to your readers the points with respect to 220-volt lamps wherein experience in your country differs from that of ours.

In the first place, of course, considerable allowance must be made in regard to this communication or what I may correctly call this interchange of opinion, in view of the fact that electrical engineers in this country have very little accurate knowledge of the manufactures and methods of supply and of the circumstances and conditions under which electric lamps are made and used in the States and *vice versa*. This being the case, I shall confine my remarks to the salient features of the paper.

With regard to the experiences of Prof. Shepardson bearing upon the general advantages of three-wire systems of supply and the difficulties which have hitherto arisen in obtaining satisfactory 220-volt lamps, I may say that they are quite in common with ours. After testing dozens of various makes of lamps, both English and Continental, I have at last come to the conclusion that only about three or four firms can turn out a really good 220-volt lamp, satisfactory as regards life, efficiency, price and construction.

Among these manufacturers I may especially mention the following: 1. The Zurich Incandescent Lamp Company; 2. The English Ediswan Lamp Company; 3. G. Braulik, agent for the "Phillips" lamp; 4. Mr. H. M. Salmony. Of these the most successful in all respects is, in my opinion, the first-named. This is very largely due to the fact that this company has perfected a process for making an exceptionally high-resistance filament, which, as a natural consequence, enables the length to be reduced—an item of very considerable importance in the design of 220 volt lamps.

It appears from Prof. Shepardson's paper that considerable fluctuations of voltage occur on the supply mains of companies in the States, and that lamps are consequently subjected to strain which must affect any high-efficiency lamp (even lamps of 3.5 watts per candle) very seriously. In this country, however, such variations would not be allowed or tolerated. The Board of Trade margin is 4 volts above or below the declared pressure (say 220 volts) at any time and at any point in the system, no matter how extensive. This marginal limit is indeed very rarely exceeded, and in English stations, it is the custom to graphically and automatically record the pressure continuously from many points in the network of mains. Any recorded variation exceeding 4 volts above or below the mean is met by severe reprimand of the electrician who is in charge of the switch-board at the time. Immediately there is a too-heavy demand on any one section, that section, in the case of direct-current supply, is strengthened up by laying additional mains parallel to the other, or in the case of an alternating current, an additional transformer is put in. The object in both cases is, of course, to keep the "drop in volts" on the distributing mains within the limit allowed (usually 2 volts) from the feeding-point pressure.

In the latter part of Prof. Shepardson's paper the efficiency tests are very interesting, and bear out my own experience as indicated in my contribution to your June number. In that article I enumerated the points which a good 220-volt lamp should possess, and the general lines upon which it should be designed to be satisfactory in order to replace the 110-volt lamp. But there can be no question that we are yet a long way from finality in the perfection of any incandescent lamp.

Carrying Capacity of Wires.

Mr. Musgrave Heaphy, the pioneer in English electrical insurance inspection, in a recent interview with a representative of London *Lightning*, expressed himself strongly in favor of the 1000 amperes per square inch rule for the safe carrying capacity of wires. While acknowledging that small wires had, so far as heating is concerned, a higher carrying capacity than large wires, he considered that the material point was the question of corrosion. As corrosion of copper conductors is rarely otherwise than local and electrolytic, and once begun is apt to be destructive to both large and small wires, Mr. Heaphy's conclusion appears to have no real justification.

*August issue, page 312.

FUSES vs. CIRCUIT BREAKERS.

CIRCUIT BREAKERS A STEP BACKWARDS IN ELECTRICAL PROGRESS.

BY HARRY H. CUTLER.

In selecting the above heading for the subject of an article which appeared in the August number of this paper, I fully realized that such a statement could not be maintained in a single article, and I made very little attempt to do so, confining myself to pointing out a few cases where the adoption of circuit breakers was inadvisable. I also digressed from the subject by discussing at length the construction and reliability of properly designed fuses, and pointed out that such fuses are, in many cases, to be preferred to circuit breakers.

In this article I will endeavor to show, first, that circuit breakers, such as are now in general use, are designed upon wrongly applied engineering principles; and second, that circuit breakers are frequently used in places for which they are entirely unsuited. Now I submit, that if I can prove these two statements, I will establish the fact that the electrical industry, in so far as these statements apply, is taking a step backwards in electrical progress.

Let us take for our first case, the discussion of the utility of the circuit breaker when used to protect a shunt-wound, isolated motor, supplied with current from a central station. We will suppose it to be fitted with the common type of circuit breaker, which is so designed that the greater the amount of current which flows through any particular circuit breaker, the quicker will the circuit breaker open.

The principle of this type is to open the circuit as quickly as possible the instant the current becomes abnormal. This feature is bad engineering in at least four distinct and different respects, for properly protecting a motor. It is bad because the quicker the circuit is opened, the greater will be the potential of the induced, or extra current, produced in the coils of both the armature and the field. It is this high-potential current that breaks down the insulation of motors and dynamos, and the fact is too well known among experienced engineers and manufacturers to call for any proof on my part.

Furthermore, the opening of the circuit removes the very path through which this extra current could discharge without doing any damage. A premium is thus put on breaking down the insulation of the motor. As pointed out in my previous article, momentary fluctuations of abnormal currents in a motor do no harm whatever, and do not call for any protection. A circuit breaker, therefore, that opens on the instant the current becomes slightly abnormal performs, in so doing, no useful office.

Again, when abnormal currents occur, these abnormal currents are allowed to pass through the apparatus which is supposed to be protected, permitting them to get in their destructive work, and then opening the circuit as quickly as possible. It is like hitting a man a hard blow in the eye, and then jumping quickly aside and saying, "Excuse me, but you cannot be hurt, because I was very careful to strike you so quickly."

It is considered bad engineering to stop a body in motion quickly which possesses inertia. Electricity acts as if it possessed inertia in an indisputable and marked degree. It is poor engineering to put a gate valve into the supply pipe of a steam engine, and suddenly close the valve when the engine is running. It is bad practice for a fireman to close the valve at the nozzle of the hose while playing on a fire. It is bad engineering to too suddenly interrupt the flow of an electric current. There is sure to be a "kick" somewhere, and a strain that does no good.

Still again, any machine that stands idle for any length of time is pretty sure to corrode and become clogged with dust and dirt. Take a hundred circuit breakers, set them to open at 100 amperes and remain closed at 95. Install them in a cellar exposed to dust and dirt, as is usual in some classes of work, and leave them closed for a month. Then send a gradually increasing current through them until it reaches 110 amperes. I will pay any man $1 for every circuit breaker that opens, if he will pay me $1 for those that don't.

Go further, and send a thousand amperes through these circuit breakers, and I will take the odds, one to two on those that don't open. And yet it is sometimes claimed that fuses are not necessary when a motor is protected by a circuit breaker. We need have no fears, however, that any central station of importance would follow such advice as this.

Having pointed out why the usual type of circuit breaker may fail to protect, I now confidently claim that its use, as applied to stationary motors above described, is a step in the wrong direction, and constitutes a distinct step backwards in electrical progress. I could take up the application of the circuit breaker to railway work, and bring out through similar, but slightly different reasoning, that it may be a nuisance in this class of work; that its application to street cars would place a premium on the ignorance of motormen; that used in connection with generators operated by water wheels, it is positively dangerous, and that its application to alternating-current motors and for the protection of electric-lighting circuits, is utterly ridiculous.

It is not, however, a difficult matter to construct a circuit breaker that will avoid the main objections possessed by the type now in use, which would not be a nuisance, and would constitute a step in advance, and not backwards, in electrical progress. Such a circuit breaker, should, I believe, have the following qualities:

First, its initial movement should not open the circuit; second, it should introduce sufficient resistance into the circuit to cut down the current to a safe amount, and then open the circuit; third, it should introduce this resistance instantly only when the flow of current is extremely abnormal; fourth, it should not act at all on a flow of an abnormal current lasting only a short interval of time; fifth, it should act when a slightly abnormal current continues for a long time; sixth, the time which elapses before it starts to open should be governed by the temperature of the electrical devices which it protects; seventh, whenever possible, it should divert abnormal currents from going through the apparatus to be protected.

Requirements three to six constitute what I mean by saying that a circuit breaker should have a time limit. The operation of the ideal circuit breaker depends upon the combined magnetic and heating effect of the current, and not upon the magnetic effect of the current alone, as is the case with all the circuit breakers I have ever seen put on the market.

The first requirement of a circuit breaker, I say, is that it should not at once open the circuit. The object of this construction is to cut down the potential of the induced current in motors or generators, and also to lessen the mechanical shock upon the system. It is evident that this requirement would not be necessary in all cases. The value of the time limit feature will, I believe appeal to any engineer who has read both of my articles on circuit breakers. The seventh requirement is well illustrated by the magnetic release applied to motor-starting boxes, and also in most makes of lightning arresters.

The worst possible strain, both electrically and mechanically, to which a shunt-wound motor can be subjected, is to have the current switched on at full potential when the armature is standing still and with no external resistance in its circuit. Such an accident as this is, however, very common, and when Prof. Geo. D. Shepardson conceived the idea of protecting a motor from this damage by holding down the switch with a magnet energized from the same source as the motor, he showed high-class engineering ability, and brought out and patented a device of such undeniable utility that it has been appropriated by every motor manufacturer in the United States with whom I am acquainted.

The requirements which I have laid down for a properly designed circuit breaker are not impracticable nor at all difficult to meet, and, in fact, have been incorporated by the writer in several devices of his design. Having severely criticized the circuit breaker in common use, I will give the chief features of this type for criticism in return.

A motor starter, fitted with this circuit breaker, will open the circuit of an overloaded motor with absolutely no spark or strain on the insulation of the motor. As applied, for example, to a 15-HP 220-volt elevator controller, it tests out about as follows:

With a cool armature, a current of 100 amperes or over opens the circuit in a fraction of a second; 90 amperes will flow for about one and one-half seconds before the circuit breaker will open; 80 amperes will flow for three seconds, 70 amperes for nine seconds and 65 amperes for fifteen seconds; with 60 amperes the circuit breaker will not open at all.

When the circuit breaker opens, it resets itself on moving the elevator-controlling

cable to its central position. If the motor has been worked hard and has gotten heated up, the circuit breaker will act more quickly, in proportion to the elevation of the temperature of the motor.

In conclusion, I submit that the function of the ideal circuit breaker is to protect electrical apparatus from two main destructive effects of abnormal electrical currents, namely: First, the heating effect, and second, the inductive effect or power to break down insulation. In order to protect against the heating effect it is not necessary to operate the protecting devices until the apparatus to be protected approaches a dangerous temperature; and to protect the insulation of electrical apparatus, the circuit should be opened through resistance.

I therefore submit that any circuit breaker whose action depends entirely upon the magnetic effect of the current constitutes a distinct step backwards in electrical progress.

CIRCUIT BREAKERS AND FUSES.

BY F. V. HENSHAW, MEM. A. I. E. E.

Recent articles on the above subject, while giving much valuable information, are yet open to criticism in certain particulars.

The controversy as to whether the circuit breaker or fuse should be adopted to the exclusion of one of them as a protective device seems to the writer to be a mistake, as both have a distinct value under different conditions.

A protective device suitable for an ordinary motor equipment is not necessarily adapted for use on a railway-station switchboard. For in the first case, if the motor is properly installed the device should never act except in case of accident at rare intervals, while in the second case the device is frequently in action under normal conditions. The motor should also be protected from injury by a device whose limit current is accurately fixed, while ability to close the circuit again with great rapidity is not of importance.

On the station switch-board the conditions are the reverse, for the surplus power is so considerable that great accuracy of limit current is not required, while ability to close the circuit instantly after a "blow" is of great importance. It may be also mentioned as a point worthy of consideration, that the expense of a circuit breaker is much greater than that of a fuse where the device seldom operates, while in cases where it operates frequently the circuit breaker is decidedly more economical. A protective device adapted to all cases in electric lighting and power work should meet the following conditions as nearly as possible:

1. The circuit should be opened when the current reaches a fixed maximum limit, whether the increase be gradual or sudden.
2. The device should be capable of calibration so that the limit current is but little in excess of the maximum normal current.
3. In case of short circuit the line should be opened without arc or flash.
4. Under no conditions should any part of the device become hot enough to cause damage to itself or danger to surrounding combustible material.
5. The device should admit of the instant closing of the circuit after it has come into action to open the circuit.
6. The device should be unaffected by variation in local conditions of temperature, exposure or position.
7. The design should be such as to prevent tampering by irresponsible persons, tending to change the limit current or render the device inoperative.

While it is desirable to combine all these qualities in one device, yet it is evident that they are not of equal importance in the various conditions met with in practice. In the central station Nos. 1, 2, 4, 5 are required, while the others are not essential. For outside work on customers' premises all the conditions except No. 5 are important, and a close approximation in the first two is generally more necessary than in the station. From these considerations and the results of many practical tests and experiments the writer concludes that the circuit breaker is best adapted to the first class of work above, while a fuse device can best be used for the second class.

No circuit breaker in existence will meet condition No. 3, while there are fuses on the market which do so perfectly.

Therefore the writer further concludes that the fuse device can be made to meet *all* the conditions mentioned more nearly than the circuit breaker.

In Prof. Stine's recent article* in these pages, the statement that the film of oxide on the surface of a lead fuse forms a tube capable of preventing the rupture of the molten wire, seems open to question.

If a moderately heavy fuse be blown on short-circuit in the open air, this oxide will be seen floating in the atmosphere in long silky threads and it is difficult to conceive of an extremely thin tube of such a substance supporting any appreciable quantity of melted lead. Referring to the same article, it is stated, in connection with the protection of electric motors, that the starting current should in no case exceed the normal rating of the motor, and further, that if it does so exceed the starting torque will be decreased by armature reaction.

Such a limitation of starting current would be very unsatisfactory, as there are many cases where it is desirable to make the starting torque greater than the rated capacity running torque, and such increase can best be obtained by increasing the armature current.

A shunt motor in which increasing armature current decreased the torque would have to be so devised that the armature reaction reversed its usual effect and to such an extent that the effective field strength would be reduced in a greater ratio than the armature current increased in value, which is not common practice. Furthermore, "the normal rating" of a motor is by no means a fixed quantity, being largely a question of temperature to suit various tastes within wide limits.

Prof. Stine refers to a type of fuse enclosed in a tube packed with non-conducting material as an excellent device, except that, being supported throughout its entire length, it will carry a great overload without rupture. This is quite true, but the only fuse of this type that the writer is familiar with has not this objection, as a central air space is provided whereby the limit current can be accurately adjusted.

*AMERICAN ELECTRICIAN, September, page 350.

Properly constructed fuses of this type can be made to very closely approximate all the requirements of a perfect protective device. In the excellent article of Mr. Woodbridge in the August issue, on fuse design, the use of high-resistance, low-melting point alloys is condemned and his conclusions are rather in favor of copper. For fuses of small capacity the mere mechanical strength of the fuse wire is an important factor, and such alloys are useful to obtain this. The great heat conductivity and high melting point of copper are also against it for use as a fuse metal.

A copper wire fuse might become red hot and remain so for a long period, which would not tend to improve its condition, and the sensations of the insurance authorities at the thought of such a possibility may be imagined.

Mr. Woodbridge's formula $(SH \times T + LH)\frac{D}{T}$ indicates a metal in which the specific heat, latent heat and specific resistance are low with a high melting point. A metal having these properties to a high degree might not be suitable for commercial work, as such work demands a fuse that will carry at least a 25 per cent. overload for a few seconds. To obtain the exact degree of "sluggishness of blowing," neither more nor less, is the critical point in the design of a protective device, and the writer's observations indicate that it can be accomplished more accurately with the fuse type than with the circuit breaker.

AN ACCURATE AND RELIABLE FUSE.

BY LOUIS W. DOWNES.

While the causes of the unreliability of the fuse have been very thoroughly treated by many writers in the technical journals for some time past, few, however, have attempted more than to suggest possible means of eliminating the faults described, and these suggestions have been generally of a theoretical rather than practical nature. A lengthy discussion of the causes of failure is, therefore, hardly necessary since they are so well understood, but a description of a method which has been found most successful in eliminating them, will, I believe, be more interesting.

A consideration of two principal defects—a variable melting point and a tendency to destructive arcing under heavy overload or short-circuit—will show, as has frequently been pointed out, that these are more largely due to the improper conditions imposed, than to any inherent defect in principle. A variable melting point may result from several causes, such as location, exposure to draught, contact with adjacent bodies, variation in length or irregularity of cross sections, the size and composition of terminals. The first three, however, have less attention paid to them, and are consequently the chief causes of error in this direction. A fuse exposed to a strong draught

will naturally carry a larger current without melting than one so placed as to be free from draught; again, a fuse left in contact with a body a better heat conductor than air will act in the same manner, and it is astonishing how great an effect the slightest contact will have.

I have observed instances where contact, not extending more than ⅛ in. in a total length of 2½ ins. with so poor a heat conductor as paper, would change the time of blowing for a given current about 30 per cent. A sensitive device is demanded, and yet objection is raised when it demonstrates its sensitiveness.

Obviously we have then, as the first steps, to so enclose the fuse that it is completely protected from draughts; to so support it that the extent of the contact, if any, with adjacent bodies is a fixed quantity; and further, have the length and diameter of the fuse metal and the size of the terminals always the same.

The objection will at once be raised by many engineers that a fuse so enclosed will have a greater tendency to arc than when in open air, and this may in a measure be true, unless precautions be taken to overcome such tendency. The fault of arcing under short-circuit is a much more serious trouble when we consider high-potential circuit. With low-potential main-line cut-outs and branch blocks, I believe it to be due largely to imperfection of design.

The distance between centers is often ridiculously short, often much less than the length of the fuse, which has consequently to be bent to get it into place; and little or no attention is given to the amount of energy represented by the severe discharge of a short-circuit or sudden heavy overload—convenience and appearance having apparently determined the proportions of such devices. If we consider that an arc is the result of the formation of a stratum of vapor due to the volatilization of the fuse metal, and that once formed tends to feed itself by destruction of the terminals, the matter of overcoming it is not so difficult as might at first appear. To prevent its continuance, we have naturally to break up or interrupt this vapor, as we would a metallic circuit, and then dissipate or remove it.

That such is the case may be easily shown by the experiment of short-circuiting a fuse, placed first in a horizontal position, and then vertically. If the fuse be moderately long, say, 5½ or 6 ins., and covered with a porous flexible tubing, a 500-volt circuit can be short-circuited through one of as high as 30 or 40 ampere capacity, without any more disastrous results than scorching the terminals and blacking the base. With the same length of fuse and the base set vertically, the results are totally different. It is impossible to short-circuit even a 5-ampere fuse in this way without destroying the fittings, an arc of the most vicious nature being established, which will hold until the terminals are completely destroyed and the base melted into an almost unrecognizable mass.

The reasons for this are very evident. In the first instance, the vapor heated by the discharge naturally rises, thus increasing the length of the circuit; and as its density, and with it its conductivity, is also continually diminishing, the arc is unable to follow. The rapidity of the action is, of course, materially increased by the explosive nature of the discharge. In the second instance, however, this very thing assists the establishing and the maintenance of an arc, since the heated vapor passes directly from the lower to the upper terminal, providing just the path that we should wish it to avoid.

Our reasoning has so far shown us the necessity of enclosing the fuse within a tube to protect it from air currents; it has also shown us that unless further precautions are taken the tube will confine the vapor formed upon short-circuit, aiding materially to establish an arc. Should we now fill one enclosing tube with a suitable, finely divided material we have nearly solved the problem of producing a reliable fuse, for we have complied with nearly all the necessary conditions. It is protected from air currents; it is rigidly supported and cannot change its position; and finally, the multitude of minute paths provided in the spaces between the particles of the filling, disintegrates or divides any vapor formed upon the rupture of the circuit, cooling it and allowing it to escape, so that as there is no continuous stratum of vapor between the terminals, an arc cannot be maintained, even under the most exacting conditions.

A new difficulty, however, here presents itself, due to the fact that the fuse is in contact with another body of variable heat-conductivity throughout its length. If the surrounding material be cold, the heat due to the passage of any given current is at first conducted away very rapidly, with the result that the melting point of the fuse is carried far beyond its melting point in air, for a given time-value.

For example, a certain 10-ampere fuse, 3½ ins. long, was found to blow in air at 15.8 amperes in approximately thirty-two seconds, under favorable conditions. The same fuse enclosed as described will carry 50 amperes for one minute, if cold at the start, or it will carry 30 amperes for thirty minutes. There is what might be called an absorption of heat by the surrounding mass, which is gradually raised to a high temperature, the rate of absorption becoming less as the temperature rises until the melting point is reached.

This effect would, of course, be disastrous in practice, since the melting point would vary according to the length of time the fuse was in circuit; that is to say, it would gradually decrease. Our first effort to overcome this defect was to increase the radiating surface, but this was ineffective, due to the fact that both the tube and filling were too imperfec conductors of heat to be influenced by any material increase of surface. The method then adopted and found to answer all requirements, was to preserve an air space at the center of the tube within the filling.

Small paper drums or closed cylinders are slid over the fuse wire and secured at the center. The air confined in this way, being a poor conductor of heat, prevents its too rapid absorption at that point, the result being that the melting point is always the same; that is to say, with any given fuse, the melting point always occurs in the same time for any given current.

Reference to the accompanying illustration (Fig. 1) will show the arrangement we have found most satisfactory for the purpose. The fuse wire or link is soldered to copper terminals at points *B* and *C*, the air drum, *A*, having first been threaded over the fuse and fixed in place by cement. It is then placed within the tube and the filling packed tightly around it, the ends being closed by suitable brass caps, in which are cut ventilating slots to allow the vapor produced on short-circuit to escape, and to these caps are soldered the terminals.

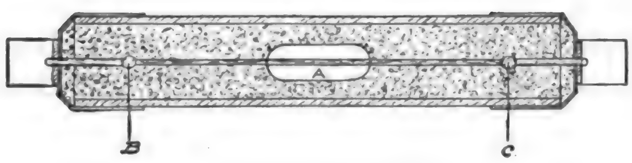


FIG. 1.—ENCLOSED FUSE.

In this manner the defects of the fuse may be overcome. In the first place, its length becomes a fixed value, as are also the dimensions of the terminals. It is rigidly supported in a fixed position, which cannot be changed by careless workmen; its insulating covering and the fixed volume of air at the center prevent variation of the melting point, which will be found accurate as regards time and current value to within a small percentage: and finally, upon short-circuit there is no discharge, flame or noise, and the arc will not be maintained. We have frequently held a fuse in the hand and connected the terminals directly across the mains of a 400-KW, 2000-volt alternator, and could only determine that the fuse had blown by feeling a throb in the tube similar to a pulse-beat.

We have enclosed these fuses in an air-tight box connected with a U-gauge, and upon a short-circuit discharge the liquid would slowly rise, showing but 1.28 oz. per square inch increase in pressure developed, the internal dimensions of the box being but $7 \times 2 \times 3$ ins.

The question of the composition of the filling in the tube was soon found to be an important one. Starting with coarsely granulated marble and with sand, it was found that in fuses above 3- or 4-ampere capacity, there was, on short circuit, heat enough developed to melt the silica in the filling, and this combining with the metal of the fuse, formed a peculiar species of slag or glass. Under certain conditions with fuses of high capacity, this slag would completely stop the ends of the tube a short distance from the drum, and prevent the escape or dissipation of the vapor, with the result that an arc of the most destructive character would be maintained, sometimes burning its way through the sides of the tube, at others bursting it open with great violence.

With a filling of this nature in a tube whose capacity was great as compared with the amount of metal in the fuse, a short-circuit would result in the formation of an elongated cylinder of the slag which was readily removable from the case. With some kinds of filling, the material forming the cylinder produced in this way, was so

hard that it would readily cut glass, and was probably similar to carborundum in its nature. Fig. 2 shows a photograph of such a formation. It is hollow, with closed ends, and about 6 ins. long. The opening at the middle of the length is where the arc burst through and would, in all probability, have eaten its way through the enclosing micanite tube used in this experiment, had it not been interrupted at another point. A filling was finally discovered which answered all requirements, as there was no melting or combination between it and the metal, examination after short-circuit only showing the mass to be slightly blackened at the center.

Upon this principle we have constructed fuses up to 100-ampere capacity (and by this I mean one that will carry 100 amperes indefinitely), and short-circuited them on a 500-volt power circuit without flash or discharge of any nature. We have also constructed fuses for 1000- and 2000-volt circuits (alternating) with perfect success, although we are limited here as to ampere capacity on short-circuit test, for notwithstanding the machines supplying the circuits are of 400-KW capacity, we find that with a fuse of much over 20-ampere rating, a short-circuit reacts on the fields of the alternator, bringing the voltage down instantly, the current falling to a value just sufficient to melt the fuse within a second or two, more as if from overload than from short-circuit, that portion within the drum alone being melted, whereas, ordinarily, in a short-circuit, the entire fuse would be vaporized.

FIG. 2.—CYLINDER OF SLAG, FROM FUSE CASE.

While this may seem a small fuse, it must be remembered that the rating is for load-amperes, that is to say, the current that it will carry indefinitely. The blowing current for a very short period of time is much in excess of this and on short-circuit it would rise to a very high value. The fact that the field of the alternator is killed shows that the current is something in excess of the output of the machine (200 amperes) at the instant of closing the switch.

We have employed these fuses on 2000-volt alternating circuits supplying large motors, and have had them operate with the greatest success on fairly heavy lag currents. We have also tried them on long lines possessing high inductance with equally good results, and these two conditions would be about the most severe that could be imposed. In such a circuit, however, the fuse must be differently proportioned from one operating on a circuit of low self-induction, since the time-factor, which must be considerable in the former, will not permit of the instantaneous breaking of the circuit, and consequently greater provision must be made for the cooling of the arc, which thus gradually dies away. Fuses constructed as I have described have a considerable range for adjustment, since by changing the size of the drum and the length of the fuse metal, we can change considerably the capacity for any given cross-section.

The question of fuse rating is one that needs attention, and a definite standard, based upon scientific principle, should be adopted by all manufacturers. At the present time there is no definitely accepted standard; the various manufacturers use different ratings, which necessarily leads to a great deal of uncertainty and confusion, more particularly as the majority of them are based upon an arbitrary safety "overload-factor" principle. In other words, speaking literally, fuses are all rated at much below their actual carrying capacity, and as this safety factor is wholly unknown to the consumer, it is impossible to tell just to what capacity you are fusing your circuit. Moreover, as different manufacturers have adopted different standards for their safety factor, the confusion is still further increased.

I have heard it urged that an overload factor was very desirable and so it may be; but as it is impossible to determine just what factor will be correct for all conditions of service, and as no one factor can be the correct thing for all, it is obviously entirely out of the question, if looked upon from a scientific standpoint. An overload factor that would be correct for lighting service would be quite unsuited for motor service.

A careful consideration of these features has indicated that the correct method of rating should be by the maximum current that the fuse will carry indefinitely, with the surrounding temperature at 75 degs. F. In this way all but one uncertain factor is eliminated, namely, that of variation in temperature, and this is taken at a point that is generally accepted as a fair average for the interior of buildings throughout the year.

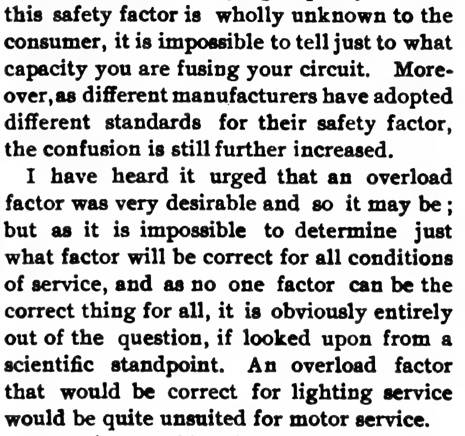


FIG. 3.—BLOWING CURVES OF FUSE-WIRE AND OF NON-ARCING FUSE.

By this method we know definitely from the marking on the fuse just what we have, and can allow any necessary overload factor according to the requirements of the service. It is the almost universal custom among construction men to fuse circuits considerably in excess of the actual load, and when this is done with fuses that are already underrated by a large percentage, it is not surprising that trouble is frequently experienced by fuses not blowing when it is thought they would or when it is necessary they should. Reference to Fig. 3 giving the blowing curves of ordinary fuse wire and also of a non-arcing fuse, will illustrate this more clearly. The rating is the same in both instances, namely, 10 amperes, but it was found that in the case of the bare wire it would actually carry 17 amperes indefinitely in the terminals used. Assuming that this ratio would hold approximately true for other sizes, in the case of fusing a 10-ampere circuit, as is ordinarily the practice, a 12- or 15-ampere fuse would be inserted. With ability to carry 70 per cent. more than the rating, we would then have, in the first instance over 100 per cent. overload and in the second over 150 per cent. The liability of overloading any circuit to this extent is certainly a most undesirable and dangerous feature of this method of rating.

The curve of the enclosed fuse shows that should by any means 30 per cent. overload come upon the circuit it will operate in 50 seconds. It may be noticed that the critical point is much closer to its maximum load current for any given time-value—a very desirable feature for certain service. This is due to the short length of the bare fuse, which was but 2 ins., and to the fact that it was held in fairly heavy terminals, while in the case of the enclosed fuse, its length was considerably in excess since the fuses tested were built to operate on a 500-volt short-circuit without arcing.

The time element in the fuse is, for certain service, a most valuable feature, notably that of motor supply, since it admits of slight overloads for some little time, but as soon as this becomes in any way excessive, the time-value is so materially reduced that danger to the apparatus is avoided. It is certainly a more reliable safeguard than any form of mechanical circuit breaker, for in the latter device the current may be long continued at a dangerous point without any action of the breakers, while in the case of the fuse the time-factor is a sure safeguard against continued overload.

In illustration of this, let us consider the case of a 10-HP motor supplied from a 500-volt circuit; the normal current at full load would be about 17 amperes, but at the moment of starting, if under full load, the current will rise to 30 amperes or more for an instant. If the current is controlled by an automatic circuit breaker, this must be set at above 30 amperes, or else it will open when the motor is started. If set at this high point, the breaker is no protection whatsoever against continued overload of anything less than 30 amperes. On the other hand, if an 18-ampere fuse of proper design was used as a protective device, the momentary current increase would not open the circuit, yet anything in excess of the normal load current would melt the fuse long before the apparatus was in any way endangered.

This matter was very clearly brought up in reference to elevator motors in Mr. H. H. Cutler's interesting article in the September issue, entitled "Circuit-Breakers a Step Backward." The position is also strongly endorsed in the English technical press. Now that it is known to be possible to construct a fuse having a high degree of accuracy of time-value, and one free from the drawback of severe arcing, I do not question but that engineers generally who have had a

practical experience in these matters, will concede the point taken, that for motor work, a properly designed fuse is for many reasons far more satisfactory as a safe-guard than any mechanical device.

RAILWAY MOTOR DESIGN.

BY ALFRED E. WIENER, E. E., M. E., MEM. A. I. E. E.

The construction of motors used for railway propulsion deviates in many respects, electrically as well as mechanically, from that of ordinary motors. The principal conditions that must be fulfilled in the design of a railway motor are the following:

1. The motor should be extremely compact so that it may easily be placed in the space available within the truck; yet it must be easily accessible, and all parts subjected to wear must be readily exchangeable. All parts of the machine must, furthermore, be so designed and the windings so executed that the continual vibrations due to the motion of the car are unable to loosen the same, or to get them out of working order.

2. It must be so designed that with minimum weight a maximum output is obtained.

3. The speed of the armature must be properly chosen with regard to the minimum and maximum load, to the speed of the car, to the diameter of the car wheels, and to the ratio of speed reduction.

4. The regulation of the speed should be simple, reliable and perfectly adapted to all grades and curvatures of the track.

5. The type of the motor should be so chosen and the design so carried out that there is no external magnetic leakage, that at the same time all the vital parts of the motor are protected from mechanical injuries, and that it can be so supported from the truck that, if possible, none of its weight is resting directly upon the car axle. Particular care must also be bestowed upon the selection of insulating materials and the manner of insulation, in order to guard the machine against the influences of dampness, mud and water.

1. Compact Design and Accessibility.

It is usual practice to equip each car with two motors which are directly suspended from the car axles and the frame of the truck; hence the extreme dimensions of the motors are limited by the diameter of the wheels, their distance apart longitudinally, and by the gauge of the track. The trucks most commonly used have 30- or 33-in. wheels, a wheel base of 6 to 7 ft., and the standard rail gauge of 4 ft. 8½ ins. The height of the motor is further limited by the condition that a space of at least 3 ins. should be left between the lowest point of the motor and the top of the rails, in order to enable the motor to pass over stones or other small obstructions accidentally upon the track. With regard to accessibility, the arrangement should be such that the working parts can be easily inspected during the trip from a trap-door in the floor of the car. If it is impracticable to provide the car barn with pits below the tracks, the motor should be so designed that the armature, the field coils, and the brushes can be taken out through the same trap-door. In order to facilitate the quick replacing of an armature, it is advisable to split the motor-frame horizontally and to make one half revolvable by means of strong hinges.

2. Maximum Output with Minimum Weight.

Since for the propulsion of every additional pound of the weight of the car a proportionate extra amount of energy has to be taken from the line, it must be the aim to make the entire equipment as light as is consistent with strength and durability. In order to reduce the weight of the motor to a minimum, it is of the utmost importance to use only the best materials suitable for the respective parts, namely, the softest annealed sheet-iron for the armature core, silicon bronze or drop-forged copper for the commutator segments, and wrought-iron or softest cast-steel for the field frame. If reduction gears are used, the pinions should be of hard bronze or of good tool steel, and the gear wheels of cast-steel or of fine-grain cast-iron. In order to obtain the maximum possible output, the magnetic circuit of the motor should have as small a reluctance as possible, and the magnetic leakage should likewise be reduced as much as possible. The former object is attained by the use of toothed or perforated armatures with very small air-gaps; and the latter by proper selection of the type and by judicious design.

The armature should be made most effective by providing it with a great number of turns; the sparking which would thus result under ordinary conditions is checked by the use of carbon brushes which are set radially in order to enable reversibility in the direction of rotation of the motor.

3. Speed, and Reduction Gearing.

The speed of the motor naturally depends upon the car-velocity desired, upon the size of the car wheels and upon the method used for the mechanical transmission of the motion from the armature shaft to the car axle. The maximum speed of the car, according to local conditions (size of town, amount of traffic in streets, etc.), varies from 8 to 15 miles per hour; the greatest speed of the car axle, therefore, provided that 30-in. wheels are used with the slow, and 33-in. wheels with the fast running cars, ranges between 90 and 150 revs. p. m., respectively.

The methods of transmission most commonly employed in electric railway cars are the double and single-spur gearing and the direct coupling; worm gearing, bevel gearing, link chains and crank rods being used only in single cases. The employment of double-spur gearing was necessary with the earlier railway motors which were run at from 1000 to 1200 r. p. m., and which, therefore, had to have their speeds reduced in the ratio of from 1 : 10 to 1 : 15. High-speed railway motors, however, on account of the noise and wear connected with the presence of four gear wheels for each motor, that is, eight gears per car, proved too inconvenient and too expensive to maintain, and low-speed motors of from 400 to 500 r. p. m., necessitating but a single spur gearing with a ratio of from 1 : 4 to 1 : 5, were next resorted to. If the spur gears for such single-reduction motors are provided with broad

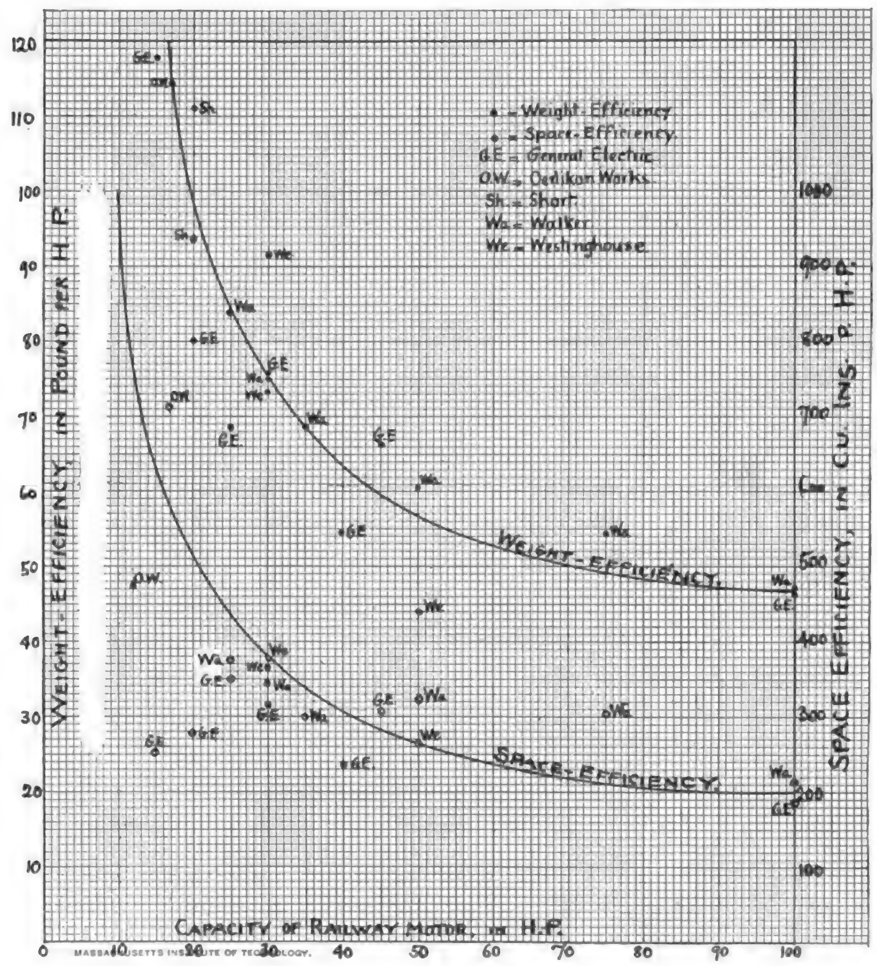


FIG. 1.—WEIGHT AND SPACE EFFICIENCIES OF RAILWAY MOTORS.

and carefully cut teeth, and are run in oil, both noise and wear are very small, and the efficiency is comparatively high. Worm gearing can be employed for any speed-ratio within the limits of railway motor reduction, and by proper design very high efficiencies may be attained. Thus, if the worm is carefully cut of a solid piece of tool-steel, and the rim of the worm-wheel of hard phosphor bronze, and if the dimensions are so chosen that an initial speed of 20 to 40 ft. per second is obtained, the efficiency, when running in oil, may reach 90 per cent. and over.*

If no speed reduction at all is required, that is to say, if the motor is to be directly coupled with the car axle, its normal speed must be between 100 and 150 r. p. m. From tests made by Prof. S. H. Short† the saving of power consumed in operating a directly-coupled, gearless street car motor is found to be from 10 to 30 per cent. as compared with double spur gearing, and from 5 to 10 per cent. as compared with single-spur gearing, according to the load.

In order to show what has been done in the way of compact design and weight-efficiency of railway motors of various speed reductions, the writer has prepared the foregoing Table I, giving the specific weight, the speed, kind and ratio of reduction, the type and dimensions of the frame, the space-efficiency, and the size of the armature, of the most common railway motors in practical use. The figures given for the dimensions of the field frame do not include any supporting or suspension brackets, lugs, or other extensions that may be attached to, or cast in one with the frame, but relate only to the magnetic portion of the field casting. This is done to bring all the space-efficiencies to a common basis, thus enabling a fair comparison of the various types.

In plotting the weight- and space-efficiencies contained in Table I, the curves shown in Fig. 1 are obtained, which clearly indicate the law of decrease of both the specific weight and the specific volume with increasing capacity.

4. Speed Regulation.

In order to enable the variation of the speed of railway motors within wide limits, their field magnets should be series wound. The strength of the magnetic field can then be regulated either by the *resistance method* in connection with partial short-circuiting of the field coils, or by the *combination method*, or by the *series-parallel method*.

In the *resistance method* the insertion of rheostat resistance into the main circuit, by reducing the effective E. M. F., causes a decrease in the speed of the motor. In this case the cross-section of the field wire must be dimensioned to carry the maximum current, but the number of turns must be chosen far greater than is required for the production of the requisite number of ampere-turns at maximum current and maximal speed. For, almost the full field strength must be obtained with a comparatively small current intensity, and it is therefore necessary to short-circuit a portion of the magnet-coils at maximum load. That is to say, in order to raise the torque of the motor for increased loads, only one of the two factors determining the same is increased, namely, the current in the armature, while the field current remains the same. In order to do this without excessive sparking caused by the fact that the brushes, not being adjustable, are never at the neutral points of the resultant field, carbon brushes must be used whose large contact resistance considerably reduces the current in the coils short-circuited by the brushes.

The *combination method* of speed regulation consists in suitably changing the grouping of the magnet coils. For this purpose it is necessary to wind the magnet coil in sections, equal portions of which are placed on each magnet, and to connect the terminals of these sections, usually three in number, to a switch, or controller of proper design. At the maximum load of the motor the three sections are connected in parallel, and for this combination, therefore, the cross section of the magnet wire is to be calculated; but for starting the car all coils are connected in series, and if no precautions were taken, the magnet winding would in consequence have to carry the full starting current, which may be 4 to 6 times the maximum normal current. In order to avoid overheating and damage due to this starting current, a starting rheostat must be placed in circuit, the resistance of this rheostat being so dimensioned that the starting current is brought down in strength to that of the maximum working current.

While with the two former methods of speed regulation the two motors of the car are permanently connected in parallel, in the *series-parallel method* of control, finally, both the armatures and magnet coils of the two motors can be grouped in any desired combination. The same number of combinations is therefore possible with less elements, and only two sections per magnet coil are necessitated. Since, by placing both armatures and all field coils in series, the starting current is considerably reduced, less resistance is needed in the starting rheostat, and a saving of energy is effected by this method. For calculating the carrying capacity of the magnet wire, the last two positions of the series-parallel controller are essential; for maximum speed the two motors, each having one coil cut out, are placed in parallel, and in the position for the next lower speed both motors with their two coils in series are grouped in parallel.

5. Selection of Type.

The most important consideration in the selection of the type for a railway motor is the condition that there should be no external magnetic leakage, as otherwise the neighboring iron parts of the truck may seriously influence the magnetic distribution, and, furthermore, small iron objects, such as nails, etc., may be attracted into the gap-

TABLE I.

GENERAL DATA OF MOST COMMON RAILWAY MOTORS.

Name of Motor.	Capacity, HP.	Weight Complete, Including Gears. Lbs.	Weight Efficiency. Lbs. per HP.	Speed at Normal Load, Revs. per Minute.	Ratio of Speed Reduction.	Kind of Gearing.	Type.	Number of Poles.	Dimensions of Field Frame. Inches. Length, ‖ Axle.	Width ⊥ Axle.	Height.	Space Occupied by Field Frame. Cubic Inches.	Space Efficiency. Cubic Ins. per HP.	Size of Armature. Inches. External Diameter.	Length of Core.	Kind of Armature. Sm.=Smooth. T.=Toothed.
Gen'l Elec. No. 6 Edison	15	1,765	117.7	1,130	9 : 1	D. Spur	Horseshoe	2	10¼	24½	15	3,770	251	9¾	10¼	Sm. Drum
" No. 14 "	20	1,600	80.0	450	5 : 1	S. "	Iron Clad	4	11½	26	18½	5,530	277	15⅞	11⅜	T. Ring
" No. 16 "	30	2,270	75.7	410	4.78 : 1	" "	"	4	13¼	30½	23½	9,500	317	18¼	13⅛	"
" G. E. 800	25	1,685	68.6	590	4.78 : 1	" "	"	2	20¼	18	24	8,740	350	16	8	T. Drum
" G. E. 1,000*	40	2,185	54.4	500	3.94 : 1	" "	"	4	16⅝	23¼	24	9,270	232	14⅛	8½	"
" G. E. 1,200	45	2,975	66.2	425	3.53 : 1	" "	"	4	24⅜	23⅝	24	13,800	307	16	13⅛	"
" G. E. 2,000	100	4,650	46.5	790	3.18 : 1	" "	"	4	25½	22½	33	18,900	189	18	13¼	"
Oerlikon Works, 12 P. S.†	12	1,975	164.5	1,150	14 : 1	Worm	Horseshoe	2	22	24	10¾	5,670	473	10½	7⅛	Sm. Drum
" " 17 P. S.†	17	1,950	114.7	450	4.9 : 1	S. Spur	Radial M.P.	4	24	22½	22½	12,150	715	15	11	T. Drum
Short, Single Reduction	20	2,220	111.0	550	5 : 1	" "	Axial M.P.	4	32½	24¾	23¼	18,700	935	21¾	5⅜	T. Ring
Walker No. 3	25	2,100	84.0	500	4.78 : 1	" "	Iron Clad	4	19⅞	21	22⅝	9,430	377	12¾	7½	T. Drum
" No. 4	30	2,250	75.0	500	4.78 : 1	" "	"	4	22	21	22¼	10,270	342	12¾	8	"
" No. 5	35	2,400	68.6	500	4.78 : 1	" "	"	4	22½	21	22¼	10,500	300	12¾	10	"
" No. 10	50	3,040	60.8	550	3.90 : 1	" "	"	4	26¼	23¾	25¾	16,050	321	15	10	"
" No. 15	75	4,100	54.7	600	3.29 : 1	" "	"	4	29½	24¾	31	22,600	301	18	8⅝	"
" No. 20	100	4,700	47.0	600	3.375 : 1	" "	"	4	24½	26	33¾	21,500	215	18	13	"
Westinghouse No. 3‡	30	2,750	91.7	300	3.45 : 1	" "	Radial M.P.	4	21	22⅞	22⅞	11,000	367	11⅝	15	"
" No. 12A	30	2,200	73.3	685	4.86 : 1	" "	"	4	21½	23½	23½	11,350	378	11⅝	8½	"
" No. 38	50	2,200	44.0	520	3.56 : 1	" "	"	4	22¾	24	24	13,100	262	13⅞	11	"

* Curves showing the performance of this motor are given in *Electrical World*, vol. xxviii., p. 176 (Aug. 8, 1896).
† The dimensions given for the Oerlikon motors are rough approximations only, the correct figures not having been at hand.
‡ For description and test of this motor, see "Dynamo Electric Machinery," by Silvanus P. Thompson, 5th edition, p. 542.

*See "Schneckengetriebe in Verbindung mit Elektromotoren," by Emil Kolben, *Elektrotechnische Zeitschrift*, Vol. XVI, p. 514 (Aug. 15, 1895.)

†"Gearless motors," by Sidney H. Short, *Electrical Engineer*, vol. xviii, p. 386 (Apr. 16, 1892.)

space and may injure the armature. In order to protect the motor from dampness and mechanical injuries such types are to be preferred, in which the yoke surrounds the armature, and which therefore can easily be so arranged that the frame completely encases all parts of the machine. The types posessing the latter feature are the iron-clad types (Figs. 2 and 3), the radial outer-pole type (Fig. 4) and the axial multipolar type, (Fig. 5) and as can be seen from Table I, these are indeed the forms of machine that are used in modern railway motor design.

CALCULATIONS CONNECTED WITH RAILWAY MOTOR DESIGN.

1. Speed of Motor for given Car-Velocity.

The speed of the motor required to move the car at a given velocity, with a given reduction gear is:

$$N = \frac{\text{ft. p. min.} \times z}{\frac{d}{12} \times \pi} = \frac{5280 \times 12 \times z \times v}{60 \times \pi \times d} = \frac{304 \times v \times z}{d} \quad . \; . \; . \; . \; (1)^*$$

in which N = speed of motor, in revolutions per minute.

v = speed of car, in miles per hour.

z = ratio of speed reduction, *i. e.*, ratio of armature revolutions to those of the car-axle.

d = diameter of car wheel in inches.

Example: A motor car which has 30-in. wheels is fitted with reduction gearing of ratio 1 : 4.; what speed must the motor be wound for, in order to give a car velocity of 12 miles per hour?

Here we have $d = 30$ ins., $v = 12$, and $z = 4$, hence by (1):

$$N = \frac{304 \times 12 \times 4}{30} = 485 \text{ r. p. m.}$$

2. Horizontal Effort and Capacity of Motor Equipment for given Conditions.

The power required to propel a car depends upon five things: Friction, grade, condition of track, curvature of track, and speed. No accurate formula can be given for the resistance due to friction, condition of track, or curvature, for this resistance will vary largely at different times with the same car, depending upon the care with which the bearings and gears are oiled, and on whether the track is wet or dry, clean or dusty, or muddy. A good average practical value of the specific traction resistance, verified by numerous tests, is 30 lbs. per ton of weight on the level, and $(30 \pm 20 \times g)$ lbs. per ton on grades, g being the percentage of the grade, that is, the number of feet rise, or fall, respectively, in a horizontal length of 100 ft. The horizontal force necessary to overcome the traction resistance caused by a total weight of W tons, therefore is:

$$f = W \times (30 \pm 20 g) \text{ lbs.}, \; . \; . \; . \; (2)$$

and the power, in watts, required to exert this horizontal effort, or draw-bar pull, at a speed of v miles per hour will be:

$$P = \frac{f \times \text{ft. p. min} \times 746}{33{,}000} = \frac{f \times \frac{5280}{60} v \times 746}{33{,}000}$$

$$= 2 f \times v \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (3)^*$$

In order to facilitate the calculation of the propelling power, or of the motor capacity required for given conditions of traction, the following Table II has been prepared, which gives the power required to propel one ton at different grades and speeds, and which, therefore, furnishes P in HP by simply multiplying the respective table value by the total weight, W, to be propelled, *i. e.*, the weight of car plus passengers (average weight per passenger = 125 lbs.):

TABLE II.

SPECIFIC PROPELLING POWER REQUIRED FOR DIFFERENT GRADES AND SPEEDS.

Percentage of Grade	Horse-power Required to Propel 1 Ton, if Rated Speed of Car, v, in Miles per Hour, is							
g.	8	10	12	15	18	20	25	30
0	.64	.80	.96	1.21	1.45	1.61	2.01	2.41
1	1.07	1.34	1.61	2.01	2.41	2.68	3.35	4.02
2	1.50	1.88	2.25	2.82	3.38	3.76	4.69	5.63
3	1.93	2.41	2.90	3.62	4.34	4.83	6.03	7.24
4	2.36	2.95	3.54	4.42	5.31	5.90	7.37	8.85
5	2.78	3.48	4.17	5.22	6.26	6.97	8.71	10.44
6	3.22	4.02	4.83	6.03	7.23	8.05	10.04	12.06
7	3.65	4.56	5.47	6.84	8.20	9.12	11.40	13.67
8	4.07	5.09	6.11	7.63	9.15	10.18	12.73	15.28
9	4.50	5.62	6.75	8.43	10.10	11.25	14.07	16.89
10	4.93	6.16	7.39	9.24	11.07	12.32	15.40	18.50
12	5.78	7.23	8.68	10.84	13.01	14.47	18.10	21.70
15	7.07	8.84	10.60	13.25	15.90	17.70	22.10	26.55

From (3) the horizontal pull required to exert a given power at given speed is found thus:

$$f = \frac{33{,}000 \times 60}{5280} \times \frac{P}{746} \times \frac{1}{v} = 375 \times \frac{\text{HP}}{v} \quad . \; . \; (4)$$

Giving to HP values from 15 to 60 HP, and to v from 8 to 30 miles per hour, the following Table III is obtained, which at a glance gives the horizontal effort, or draw-bar pull, exerted by any motor capacity at a given speed, whereupon from (2) the load, W, in tons can be computed which the equipment under consideration is able to propel at any given grade:

TABLE III.

HORIZONTAL EFFORT OF MOTORS OF VARIOUS CAPACITIES AT DIFFERENT SPEEDS

Rated Capacity of Motor Equipm't	Pull at Periphery of Wheel, f, in Pounds at Rated Speed of Car, v, in Miles per Hour, of							
HP.	8	10	12	15	18	20	25	30
15	703	563	469	375	313	281	225	188
20	938	750	625	500	417	375	300	250
25	1,172	938	781	625	521	469	375	313
30	1,406	1,125	938	750	625	563	450	375
40	1,875	1,500	1,250	1,000	833	750	600	500
50	2,344	1,875	1,562	1,250	1,043	938	750	625
60	2,812	2,250	1,875	1,500	1,250	1,125	900	750

Examples, Showing Use of Tables II and III.

1. An electric railway car of a seating capacity of 34 passengers weighs $2\frac{1}{2}$ tons, and its electrical equipment, $1\frac{1}{4}$ ton; to find the power required to propel this car at a speed of 15 miles per hour on a grade of 5 per cent.

Including the conductor and motorman, the full carrying capacity of the car is 36 persons, which, at an average of 125 lbs. per head, make a total load of $2\frac{1}{4}$ tons; the maximum weight to be propelled, therefore, is:

$$W = 2\frac{1}{2} + 1\frac{1}{4} + 2\frac{1}{4} = 6 \text{ tons.}$$

The value of the specific propelling power corresponding to $v = 5$ and $g = 5$ is found from Table II, to be:

5.22 HP,

the required propelling power, consequently is,

$$P = 5.22 \times 6 = 31.32$$

horse-power.

2. The cars of a road are equipped with two 20 HP railway motors; how many passengers can they carry up a 12 per cent. grade at a speed of 10 miles per hour?

From Table III we find, for HP = 40 and $v = 10$, a draw-bar pull of

$$f = 1500 \text{ lbs.}$$

Inserting this value into formula (2) we obtain

$$1500 = W \times (30 + 20 \times 12),$$

from which

$$W = \frac{1500}{270} = 5.56 \text{ tons.}$$

Subtracting from this the weight of the car and equipment, say 4 tons, the weight of the passengers is received, and from the latter their number is derived:

$$\frac{(5.56 - 4) \times 2000}{125} = 25,$$

which includes the attendants of the car.

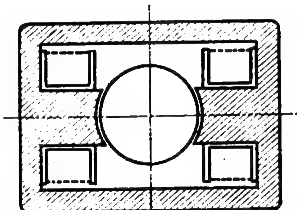


FIG. 2.

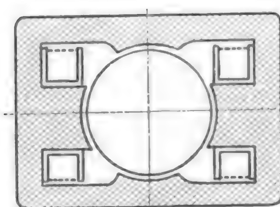


FIG. 3.

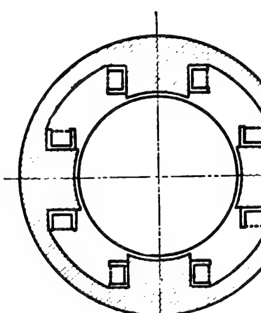


FIG. 4.

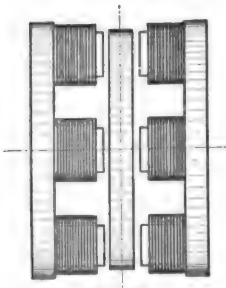


FIG. 5.

Am. Elec.

FIGS. 2, 3, 4 AND 5.—TYPES OF FIELD MAGNETS FOR RAILWAY MOTORS.

* $\frac{5280}{60}$ = multiplier to convert miles per hour into ft. p. min.; $\frac{5280 \times 12}{60 \times \pi} = 304$.

* $\frac{5280}{60}$ = multiplier to convert miles per hour into feet per minute;

746 = multiplier to convert horse-power into watts;

33,000 = multiplier to convert horse-power into foot-pounds;

$\frac{5280 \times 746}{60 \times 33{,}000} = 2$, nearly.

THERMO-ELECTRIC BATTERIES.

To the Editor of American Electrician:

I see that Mr. Reed has in your last issue a reply to my letter in the same, in which he carefully avoids any mention of the grounds upon which I base my main contention, and, therefore, he has made no answer to my communication. He restates his oft-repeated proposition that the energy of combination of carbon and oxygen is less than the energy required to decompose the electrolyte, and denies "with some vehemence" my assertion that the energy required for that decomposition is present within the cell.

I have never denied his proposition. I assume that his figures are correct, though I have not taken the trouble to verify them, because, in my view, it is of no consequence whether the energy of carbon-oxygen is greater or less than that required to decompose the electrolyte.

I will try once more to make plain the grounds of my contention.

It is a fact that oxygen is forced into the Jacques cell through the positive electrode.

I contend that this oxygen, impregnating as it does, the liquid adjacent to that electrode, constitutes an element analogous to the "depolarizing" elements of two fluid cells. As such it is, in the Jacques cell, still more important than the carbon element, for, according to Mr. Reed's own showing, it would, by combining with the positive ion of the electrolyte, evolve more energy than does the carbon by combining with the negative ion. In fact, it is certain that the union of oxygen with the positive ion furnishes exactly the energy required for the decomposition of the eleclrolyte.

This source of energy Mr. Reed has persistently ignored. He has left out altogether the reaction between the oxygen element and the electrolyte in all his formulas. What would be thought of the man who should write the energy formula for the Grove cell and ignore the nitric acid element; or of the gravity cell and ignore the copper sulphate element; or of the Grove gas cell and ignore the oxygen element? And yet this is exactly what Mr. Reed does in estimating the energy of the Jacques cell.

I insist that that the energy, oxygen + the positive ion, *is there within the cell*, and that, with the energy, carbon+the negative ion, which Mr. Reed admits exists within the cell, it is sufficient to supply all the energy to be accounted for.

If Mr. Reed denies this will he please show how I am in error. Mr. Reed professes to have understood a statement in my first letter to mean that the carbon was oxidized directly by the free oxygen without decomposition of the electrolyte. This would be a most absurd view. Such an operation could not generate a current, for there would be no way for the current to pass across the electrolyte from one electrode to the other. I said the electrolyte was not *reduced*. It is not reduced. No positive ion can possibly be set free as long as oxygen in sufficient quantity is supplied to the cell. Oxygen is simply transferred molecule by molecule across the electrolyte, exactly as copper is transferred in a plating bath from the copper anode to the cathode, an operation which requires much or little energy according to the rate of transfer. Possibly some carbon if oxidized directly by the free oxygen. If it is, this is an objectionable "local action" wasting the carbon, which means should be taken to avoid.

I will say nothing now of the other matters in this controversy, although my convictions remain unshaken. It seems best to take up only one thing at a time.

New York, N. Y. W. A. ANTHONY.

To the Editor of American Electrician:

If Prof. Anthony were to substitute a rod of copper for the carbon rod in the Jacques cell, a zinc vessel for the iron pot and a solution of zinc sulphate for the caustic alkali and alkaline ferrate, he would not change in any way the thermo-chemical or electro-chemical relations between the electrodes and the electrolyte. According to his theory, as stated in the above communication, it would be possible, by forcing air into the electrolyte of such a cell, to evolve electrical energy by the oxidation of the copper, while the zinc would remain unchanged, the oxygen decomposing the zinc sulphate by combining with the zinc and liberating (SO_4''), which would combine with the copper. Thus, a completely exhausted Daniell cell would be capable of furnishing current in the opposite direction by oxidation of its copper electrode, if we were only to force air through the electrolyte. The two cases are exactly alike, except that the Jacques cell is at a higher temperature than the other. And it is this high temperature that supplies the heat for absorption, which alone renders the action of the Jacques cell possible, while the action of either cell at a low temperature is impossible. According to Prof. Anthony's theory, there is available energy present in a completely exhausted Daniell cell—energy obtainable from the oxidation of the reduced-copper electrode. This would give us *electrical energy direct from copper and oxygen*, and simultaneously regenerate the depolarizer of the Daniell cell. As this cell requires no heat to keep it from freezing, it should, according to Prof. Anthony's theory, operate at ordinary temperatures and give a current in the direction opposite to that which it supplied while acting as a Daniell cell.

The idea advanced by Prof. Anthony that oxygen can, *by combining with the positive ion of the electrolyte, furnish exactly the energy required for the decomposition of the electeolyte*, is nearly unique but not quite. It is the idea of the man lifting himself by his boot-straps, re-enforced by the argument that no expenditure of energy is required to do so, since his body in coming down again furnishes exactly the energy required to lift him up.

Prof. Anthony now correctly says it would be absurd to suppose that carbon directly oxidized by free oxygen could generate a current, because "there would be no way for the current to pass across the electrolyte from one electrode to the other." Yet by injecting another link in the series he sees no difficulty in getting a current by the combination of free oxygen with the "positive ion" of the electrolyte. How does the current in this case "pass across from one electrode to the other," unless it passes through the free oxygen? "a most absurd view."

In another place Prof. Anthony says the "oxygen is simply transferred molecule by molecule across the electrolyte, exactly as copper is transferred in a plating bath from the copper anode to the cathode." Does he really mean that in the Jacques cell the free oxygen constitutes either the anode or the cathode through which the current passes into or out of the cell?

If he will give proper attention to electrolytic operations, he will find that free metals and other free elements are transferred from the anode across the electrolyte only when the current passes into the electrolyte through them. A free or uncombined substance is never picked up by the wayside and transferred through the electrolyte by an electric current. The free oxygen bubbling through the electrolyte of the Jacques cell can have no more effect directly on the electric circuit than copper fillings thrown into a plating bath would have on the transfer of copper from the anode. The oxygen may act chemically on any reduced metal it finds in the Jacques cell. So also, the copper filings in a plating bath may act chemically on an acid that has been set free by the current at the anode; but such reactions have no connection with the electric current, are purely chemical and evolve no energy except heat.

If Prof. Anthony will give sufficient attention to the "depolarizing elements of two-fluid cells," he will find in all cases that they are entirely unlike his "oxygen impregnating the liquid adjacent to the positive electrode." All such fluids are distinct chemical compounds, and they "depolarize" only by undergoing electrolytic decomposition in strict accordance with Faraday's law. They supply oxygen only by the reduction of some other constituent of the compound to a lower degree of oxidation or to the free state. They never depolarize in virtue of being "impregnated" with free oxygen. This is also true of all solid depolarizers, such as the oxides of lead, manganese and other metals. Where the analogy comes in between the depolarizing fluids and free oxygen, he does not explain.

Prof. Anthony says I have "left out altogether the reaction between the oxygen element and the electrolyte" in all my formulas. If he means that I have omitted anything from the equations representing the reactions, which should have been mentioned, or that I have omitted any possible reactions, I shall be greatly pleased to know what it is. The electrical fraternity will surely join with me in gratitude to Prof. Anthony if he will supply any data that have been omitted.

It is interesting to note in this connection that Mr. J. H. Hellweg, Jr., has recently published some experiments on the Jacques cell, in which he obtained an E. M. F. of 1.11 volts, or at least 6 per cent. more than could be possibly obtained from the energy of the carbon, according to any rational theory. This "high efficiency" did not shake Mr. Hellweg's belief that the electrical energy was "direct from carbon," and it may not affect Prof. Anthony's belief, but

how he will explain such results remains to be seen. Dr. Jacques obtained also under conditions of "full load" a working efficiency of exactly 100 per cent. Such results always seem to gratify those who are getting electricity direct from carbon.

Philadelphia, Pa. C. J. Reed.

NOTES.

Calculation of the Energy Loss in Armature Cores.—In a paper read by Prof. W. E. Goldsborough before the Detroit meeting of the A. A. A. S., the character of the internal distribution of the magnetic flux in laminated iron cores was discussed. Experimental results were cited to show that the flux density in a section of the core taken midway between the poles and parallel to the shaft, is much greater near the air-gap surface than near the inner periphery. When the armature is in motion, this lack of even distribution is intensified, owing to the repelling force exerted by the eddy currents, magnetic sluggishness in the iron and the disturbing reaction of the armature currents. The experimental results were obtained by threading insulated wires through a series of holes drilled in a laminated iron core. These served as exploring coils. By taking the uneven distribution into account, the calculated core losses agree with experimental determinations without the introduction of arbitrary constants into the formulas.

Y. M. C. A. Electrical Course.—The New York City Twenty-third Street branch of the Y. M. C. A. will open its winter course of electricity the first week in October, which will again be in charge of Mr. Max Osterburg, E. E., A. M., who has lectured there for several years. This year the course will be extended considerably, being divided into two distinct sections; an elementary course starting with the principles of electricity, and an advanced course intended principally for stationary engineers, wiremen and electrical workers, in which the engineering principles of lighting, railway and power transmission will be discussed. Mr. Osterburg will visit a number of interesting installations with his students to give them object lessons of actual practice. It is also intended to open a course in physics and mechanics, if a sufficient number of applicants can be secured. Applicants can get detailed information by applying to Mr. John H. Cox, educational secretary of the branch, 52 East Twenty-third Street.

New Publications.—We clip from an English contemporary the following announcements of new publications, of which, it is hoped, English translations may appear. "Messrs. Oldenburgh, of Munich, will publish next autumn a work called 'Elektromechanische Konstruktionen,' by Mr. Gisbert Kapp. The work contains twenty-five sheets of working drawings, representing continuous, alternating, and multiphase current dynamos, transformers and motors. The text contains a complete collection of formulas and rules for designing, with typical calculations. The same firm announces the second edition of C. Hochenegg's exhaustive work on 'Conductors of Electric Lines.' Mr. Hochenegg is the chief engineer of Siemens & Halske, and his practical experience renders his observations of particular value. Prof. E. Arnold, director of the Electrotechnical Institute at Karlsruhe, is now issuing the first part of a work especially interesting to students. It contains fifty-five tables and drawings referring to the construction of continuous-current dynamos. All figures are drawn to the same scale, and details referring to output, number of turns, winding, etc., are added, so that the work will be useful to the practical electrical engineer as well as to the student for whom it is intended."

Patents and Patent Law.—A committee of the National Association of Manufacturers desires information on the following points with a view to securing from Congress legislation amendatory present patent law: 1. Should the government charge an annuity on patents in order to invalidate such ones as are not considered by the owners of sufficient value to warrant the annuity, but which, nevertheless, stand as a menace through fear of infringement to new and useful patents? 2. Should laws be passed putting a foreign patentee to the same expense in securing and holding patents in this country as in the country of said foreign patentee? 3. Would it be advisable to have separate courts for the adjudication of patents, and if not, should any change be made in the present procedure in order to shorten the time of litigation? 4. What changes are desirable in the patent office procedure relative to procuring patents? 5. Is it practical or desirable to have an international agreement whereby a patent allowed in one country may become operative in any other country concerned in the agreement, upon payment of proper fees? 6. What action should the government take with countries that allow goods to be imported and sold within its borders that are marked or represented as having been manufactured in the United States and are sold under American names, trade-marks and brands, but which, in fact, were manufactured in some other country than the United States? The above information may be communicated to Mr. P. W. Gates, 650 Elston Avenue, Chicago, from whom further information on the subject can be obtained.

Electricity at the Brooklyn Institute.—The Brooklyn Institute of Arts and Sciences has prepared its electrical programme for the coming season, which includes two courses of lectures, fourteen in number, to be delivered between Oct. 1 and May 6. Among the subjects in the first course of eight lectures are "Electrical Fountains," "Submarine Telegraphy," "Characteristic Properties of the Electric Current" and "Electrolytic Condensers of Enormous Capacity," the lecturers being Mr. T. C. Martin, Mr. Charles R. Cuttriss, Prof. W. C. Peckham and Prof. Samuel Sheldon, respectively; Prof. M. I. Pupin, Prof. Wm. A. Anthony, Mr. Nikola Tesla and Prof. Wm. E. Geyer will lecture on topics not yet announced. A course of six lectures on "The Elements of Electricity and Its Application in the Arts," will be delivered by Prof. John S. McKay on the following subjects: "Historical Development of the Subject," "Electricity as a Charge," "Electricity as a Current," "Chemical and Thermal Relations of the Current," "Magnetic and Mechanical Relations of the Current," "Electrical Radiations: The Relations between Light and and Electricity." This course will present the science of electricity in a fundamental and exact manner as it exists to-day, and each lecture will be fully illustrated by experimental demonstrations. Additional lectures will be given from time to time on subjects of special and current interest, by the leading electricians of the country. The collection of electrical apparatus belonging to the Department is now at the Bedford Park Building. This will be transferred to the new Museum Building during the year, and additions made to it. The library of the Department will be placed with the collection for use by members. Several visits to electrical stations containing new and improved appliances will be made during the year by the Department, through the courtesy of the owners of the stations. Mr. James Hamblet is president of the Department of Electricity of the Institute.

New Formula for Leather Belting.—Prof. J. J. Flather in a paper read before the Detroit meeting of the American Association for the Advancement of Science, discussed a formula for obtaining the width of leather belting when the average conditions under which it is to work are known. The ordinary formula, $b = C \times \text{HP}$ in which C has values varying form 500 to 1100 for single belting, is not generally applicable to varying conditions, and the author presented a formula which allows the width of belt to vary with a number of factors, all of which are either known or can be readily determined from the given conditions. The loss due to centrifugal effect at high speeds and the influence of the arc of contact, are recognized in many accepted rules for belting, and in addition to these, Prof. Flather takes into account the diameter of pulley when the latter is small, and also the character of joint, whether laced or a cemented splice. The formula presented is

$$b = CC' C'' k \frac{HP}{V},$$

in which the values of $CC' C''$ and k are given in tables accompanying the paper. In determining the value of C for single belting, the thickness was assumed at 0.20 in.; its heaviness 0.41 lb. per square inch section 1 ft. long; the allowable working stress 350 lbs. for cemented joints (per square inch) and three-fourths of this, or 265 lbs., for laced joints. The coefficient of friction was taken equal to 0.27 for small slip and ordinary good belting. In this determination the pulleys were assumed of approximately the same diameter, which was not less than fifty times the thickness of belt. C, under these conditions, was found to equal 800 for cement and 1050 for laced joints. C' varies from 1.4 for double belts running over an 8 in. pulley, to 1.10 for same when used with a 20 in. pulley. C'' varies from 1.33 with a least arc of contact of only 120 degs. to 0.75 for an arc of 240 degs. k is not to be considered for speeds less than 2000 ft. per minute. For 2500 ft. $k = 1.06$ for cemented joint, and for a speed of 5000 ft. $k = 1.34$.

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Rotary Converters for Electric Railway Service.

In another column we print an interesting article by Dr. Bell on rotary converters and their application to electric railway service. The explanation given of the principles of this apparatus is most admirable for simplicity and clearness, and should lead to a better understanding of this simple machine. The best light in which to view the action of a rotary converter is, as pointed out by Dr. Bell, to consider that the armature has fed to it the same current which would be produced in the conductors of the armature if the apparatus were run as a generator, which current is then commutated in the usual manner.

Perhaps some day induction motors may be used in electric railway traction, but at present that prospect appears remote. In the meantime, the rotary converter enables advantage to be taken of the most valuable feature of alternating currents—their adaptability for the transmission of large quantities of energy over long distances with a minimum expenditure of copper. When extensions to present roads are made distant from the power station, a small wire leading to a rotary converter installed in a small and inexpensive room situated at the most economical feeding point—this in many cases will furnish an ideal solution to the problem of power supply. Another marked advantage is that the use of the rotary converter involves no change whatever in the car or overhead equipment, since it feeds to the trolley line a direct current the same as that supplied from the usual railway generator, and of the same voltage. That portion of Dr. Bell's article in which the rotary converter is discussed from the commercial standpoint will be found instructive, the question being treated in a manner so simple that, with the aid of the illustration given, any one interested can easily apply the method to a case in hand.

Circuit-Breakers and Fuses.

In this issue are several additional contributions to the interesting discussion on circuit-breakers and fuses, commenced in our August issue. This time the advocates of the superiority of the fuse over the circuit-breaker have the field to themselves, which reverses the situation of recent years, when nothing but abuse was the share of the former, with no one to raise up a voice in defence. In point of fact, however, the claims for the superiority of the fuse are not based upon the plain type of fuse formerly condemned, but upon a new type to which the several articles refer, and which is described in detail in the article by Mr. Downes. Should the claims made for this type be substantiated in practice, it will certainly be accepted as a vast improvement over the plain fuse. It should be added that the claims are based upon a sound principle —the elimination of the variable elements which render the plain fuse necessarily unreliable.

That this or any other fuse will displace the circuit-breaker, however, does not follow, for the latter has peculiar advantages for certain services, as pointed out by Mr. Henshaw, such as where it is frequently in action under general normal conditions, as on power-house switch-boards, and for use on switch-boards generally. Mr. Cutler in his article returns to the attack on the circuit-breaker, this time giving his reasons in detail for condemning it. He also makes reference to a type of circuit-breaker which, by introducing a time lag, obviates an objection he has urged against those now in use, but absence of details prevents any opinion to be formed as to its practicability. There can be no doubt, however, as to the soundness of the principles upon which it is said to be based—that the heat generated by an abnormal current, and not necessarily the current itself, is what needs to be protected against; and in breaking circuit, strong inductive discharges liable to break down insulation, should be guarded against.

The Niagara Conventions.

The fact that Niagara Falls has become an electrical Mecca has recently been emphasized by the meeting there during the past several months of the conventions of the National Electric Light Association, the Association of Edison Illuminating Companies, and the New York State Street Railway Association, while during the present month the delegates to the annual convention of the American Street Railway Association will gather at the same place. The meeting of the latter body promises to be the most successful in its history, both professionally and commercially. The programme of papers has been well selected, and several weeks ahead of the meeting all of the very extensive space provided for trade exhibits had been taken up.

At the meeting of the Edison Association President Insull delivered his opening address in public instead of behind closed doors, as had thereto been the custom. We regret that lack of space prevents us from printing in full this able address, which contains several matters of general interest. One of these is a recommendation that the association adopt a uniform system of accounts whereby comparisons may be made between the results obtained by the various companies operating under similar conditions. As has been well known, some of the larger companies have for several years been in the habit of comparing details of cost and charges with much benefit to each other, and if such a form as was proposed were

prepared and published, it would serve as a basis generally for central stations, both for purposes of comparison and as an aid in determining real cost of product. In the discussion of a paper by Mr. J. W. Lieb on "Methods of Charging for Current." Mr. W. S. Barstow recommended a double rate system with a continuous minimum rate in effect at all but the "peak" hours, during which a maximum rate would be charged. He favored the use of the Kapp meter system, which consists of a clock in connection with an ordinary meter, the clock shunting a smaller proportion of current through the meter during minimum hours than during "peak" hours.

Alternating vs. Direct Currents.

One of the bulwarks in this country of the direct current since the introduction of the alternating current, has been the Edison Illuminating Companies, and the partizan stand of this powerful interest has, until recently, unfavorably influenced opinion generally as to the superior merits claimed for the latter. One of the reasons for the position taken by these companies has undoubtedly been that their system of underground distribution, in which many millions of dollars have been interested, is not adapted for alternating currents. It has been known for some time, however, that the policy referred to has been undergoing a change, and in a paper read by Mr. L. A. Ferguson at the recent meeting of the Illuminating Companies at Niagara, two systems that have met with favor were described, each employing the alternating current, but retaining the present continuous-current system of distribution to consumers.

Of the two alternating-current systems referred to, one is that now being installed in Brooklyn, which will displace all the direct-current machinery now in use in the various Edison stations of that city. This consists in the employment of three-phased generating machinery in a main station, with rotary transformers in sub-stations feeding direct-current into the present Edison mains. The current will be generated at 6600 volts, stepped down by transformers in sub-stations and transformed to direct current at from 115 to 130 volts. The efficiency of this system from main station to sub-station switch-board will be, it is stated, from 84 to 86 per cent.

A second method described is one which will ultimately be adopted by the Chicago Edison Company, and calls for generators similar to rotary transformers, but reversed in action, consisting of machines giving three-phased currents and direct current simultaneously. The alternating currents will be stepped up by transformers, transmitted to sub-stations, and there presumably stepped down, converted into direct current by rotary transformers and fed into the distributing system; it is also proposed to drive arc machines in some of the sub-stations from the shafts of the rotaries which, at the same time, will feed direct current into the mains. The direct-current side of the generators will feed directly to the bus-bars of the main station, from which the supply of current for the neighboring district will be taken. The efficiency of this system from main-station to sub-station switch-board is stated to be 84 per cent. That by such roundabout methods in the utilization of alternating currents efficiencies as high as those given can be obtained, is surprising and, it may be added, extremely creditable to the alternating current.

Inductance.

One of the difficult points to the beginner in the understanding of alternating currents is that which relates to inductance. The difficulty, however, disappears if the few simple fundamental principles involved are clearly grasped. One of these is that if the number of lines of force embraced by any closed circuit is changed, an E. M. F. is set up in that circuit, depending for its value on the number of lines changed in a given time. Another is that the alternating current flowing in any circuit depends upon the free or resultant E. M. F. in that circuit, which may differ considerably from the E. M. F. measured at the extremities of the circuit.

An alternating current at every instant of time is either increasing or decreasing in value, and since in a given circuit a definite number of lines of force exist for each value of current, during any given portion of a period a definite number of lines are added to or subtracted from the circuit. In passing in or out of circuit these lines may be considered to cut the enclosing conductor or conductors, in the same manner as the movable conductors of an armature cut the stationary lines of the field of a dynamo. In other words, an inductance (such as a coil) in an alternating-current circuit may be considered as a generator of E. M. F. exactly similar to a dynamo. According to Lenz's law—which is merely a special statement of a general law of nature—when a variable current in an inductive circuit is rising in value, the E. M. F. set up in the manner described will act against the current and tend to keep it from increasing; while when falling in value, the action will be reversed, the E. M. F. tending to keep the current from decreasing in value. That is, in the first mentioned case, the inductance considered as a dynamo will generate an E. M. F. opposing that supplied at the binding posts, while in the second case it will generate an E. M. F. assisting the impressed E. M. F.

Every loop carrying an alternating current has inductance, since the lines of force accompanying the current cut in and out of the loop as the current varies in value. A transmission line, for example, is a single loop, and a coil consists of many loops, each of which is cut by lines of force from all the loops. If iron is contained within a coil, more lines of force will be enclosed, due to the greater permeability of iron over air, or the greater capacity of the former for lines of force. The considerations above mentioned are all that usually need to be considered in order to understand the effect of an inductance on a current flowing in the circuit in which it is contained.

Suppose an alternating current flowing in a coil, and consider the conditions existing with respect to E. M. F. When the current is rising, the free or resultant E. M. F. is the difference between the E. M. F. supplied to the coil, and the inductive E. M. F.; when the current is falling, the free E. M. F. is the sum of these two quantities. But it happens that at certain points of a period the inductive E. M. F. has the same value as the E. M. F. supplied; consequently, when these values are equal, the free E. M. F. is at zero, for if both are positive their difference is zero, and if opposite in sign their sum is zero. That is, when the impressed E. M. F. has a value equal to but opposite to that of the inductive E. M. F., the free E. M. F. is zero, and since the current follows the free E M. F., that also is then at zero value.

This, it will be seen, very simply explains why there must be a difference of phase between the current and impressed E. M. F. of an alternating-current circuit containing an inductance, for the impressed E. M. F., or E. M. F. at the extremities of an inductance, has its zero value at another time than when the current flowing is passing through zero, or the two are not in phase. This method of viewing inductance has the advantage that it keeps separate the two factors opposing flow of current—ohmic resistance and inductive E. M. F.—which generally are combined under the name of impedance, thereby totally obscuring the physical actions involved. We will add that this subject has been treated in detail in "Lessons in Practical Electricity," the current installment of which appears on page 407.

CONSTRUCTION OF AN ELECTRICAL TESTING SET.—I.

THE BRASS WORK.

BY JAMES F. HOBART, M.E.

It is a *sine qua non* that every electrician should have some kind of a testing set, preferably a good Wheatstone bridge fitted with reflecting galvanometer. It is also desirable that the "Electrical Worker" should be provided with some form of measuring instrument. A good testing set costs at least $100. The man who is skilled enough to work upon electrical mechanism certainly knows enough to make for himself a good measuring instrument at a small fraction of the above cost, not counting his time.

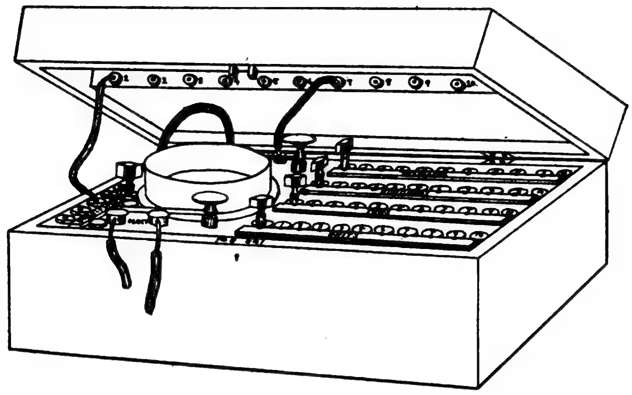


FIG. 1.—BRIDGE COMPLETE.

The engravings presented herewith are reductions of working drawings of a measuring instrument constructed by the writer. Fig. 1 presents the perspective view of the finished instrument with the exception of the galvanometer, which is not shown in detail. This instrument is patterned after a well known form now in the market, but it possesses several peculiarities of its own which tend not only to cheapness and ease of construction, but also add largely to the capacity of the instrument. It is fitted with the usual banks of units, tens, hundreds and thousands of ohms resistance; also with the usual multipliers and dividers. The direct reading capacity of the instrument is 11,110 ohms.

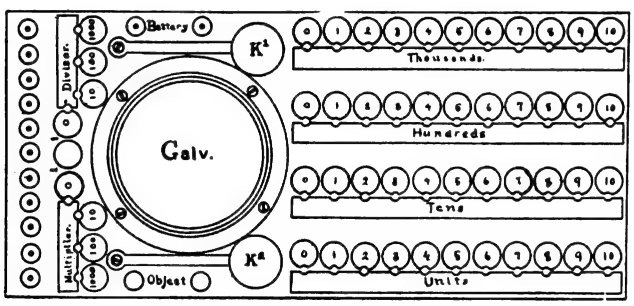


FIG. 2.—PLAN OF BRIDGE.

The instrument as sold in the market has a multiplying and dividing ratio of 10 to 1000, or a ratio of 100, thus giving a greatest capacity of 1,111,000 ohms. The least capacity or the lowest fraction to which the instrument will measure will be .01 ohm. The instrument about to be described has two additional resistance coils of one ohm each, which, with the addition of two plugs, causes the capacity of the instrument to be increased tenfold in both the maximum and minimum measurements, giving therefore a range of 11,110,000 down to .001 ohm.

The "store" instrument contains a battery of ten cells, in the top part or cover of the box, as shown at 1, 2, 3, etc. The instrument as constructed by the author has dispensed with the hard-rubber cells containing the elements, and has substituted instead a piece of plain pine or mahogany wood, through which ten holes have been bored, and small glass vials, each containing a pair of elements, are cemented into the holes bored in the wooden block. The cost of the battery is thus reduced very considerably. The writer constructed one hard-rubber battery box, as will be described later, but he begs to be excused from any further work in this direction. The glass-vial method is much better and entails not one-tenth of the work.

The box and its making will be described in due course; but first, attention will be given to a plan of the instrument as shown by Fig. 2. No attention will be given to dimensions in the description of these drawings, as blue prints from full-size figured working drawings may be obtained from the author at cost of blue printing, by any one who wishes to construct the instrument.

In Fig. 2 the plan of the box is so plainly shown that but little description is necessary. I wish to call attention, however, to the additional coils and the two plugs mentioned above. The coils are located at *l* and *l*, connecting the contact pieces; *o* and *o*. This matter will be fully described in its proper place.

The multiplying, dividing and resistance coils are shown as marked. At the extreme left of the instrument is a set of ten coils of one ohm each; they are to be used for reducing the battery current when using a heavy battery, or when connection is made with electrical power generating instruments. By connecting one pole of the battery at *o*, and the other pole at any point between 1 and 10, any number of ohms within that compass can be interposed between the battery and the galvanometer.

The first step towards the mechanical construction of the instruments is shown by Fig. 3. A piece of hard rubber 5½ ins. × 12 ins. long and ⅜ in. thick, must be selected and dressed up to exactly the above dimensions. The holes are to be drilled as shown in the illustration; the large hole is to receive the galvanometer case, and it may be counter-bored as shown in the section at the left, or the hole may be made plain and the ring (Fig. 16) which holds the galvanometer in place may be counter-bored instead of the hard-rubber base-board.

In the box under discussion, the latter method was adopted. In one other point the box differs from the drawings, and that is, in Fig. 28, which will be referred to in a future issue; this is merely the bottom of the galvanometer box, made to go inside of the brass shell (Fig. 17). By chucking the base-board (Fig. 3) and using a thin cutter, the galvanometer hole may be neatly bored out and the piece of hard rubber which is removed therefrom will be found just the thing to be utilized for the bottom of the galvanometer box inside of the piece of dry pine wood shown by Fig. 28.

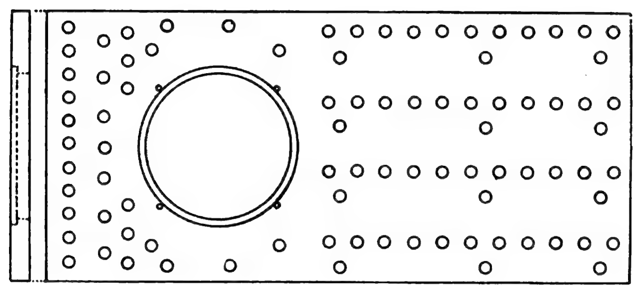


FIG. 3.—HARD RUBBER BASE.

I would by all means advise the electrical worker to make a templet of the base-board.

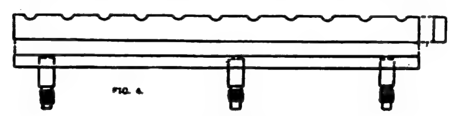
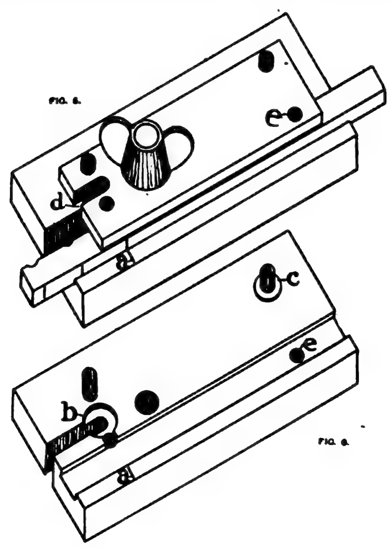


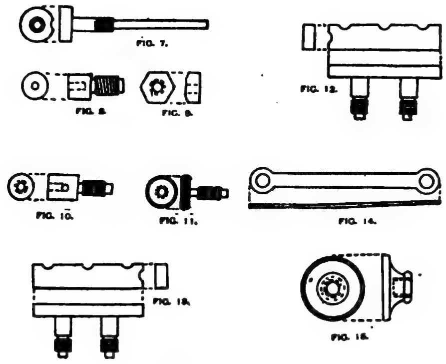
FIG. 4.—CONTACT STRIPS.

It will be noticed that of the four rows of holes at the right, each one is like the other, and one small templet may be used to lay them all out upon the main templet. For the holes at the left for multiplying, dividing and resistance contacts, two templets need not be made; one being designed for one half the box, it may be turned bottom side up and used for the other half, but this reversing should be done in laying out the



FIGS. 5 AND 6.—DRILLING JIG.

main templet; it should not be applied directly to the hard rubber. The brass or steel templet having been drilled, it is comparatively easy to make the hard rubber base-board by clamping on the templet and drilling through it. A base-board can be made by laying out and drilling holes without the use of a templet, but the best results cannot be secured, as owing to the soft nature of the rubber it is almost impossible to change the location of a hole ever so slightly after it has once been commenced.



FIGS. 7 TO 15.

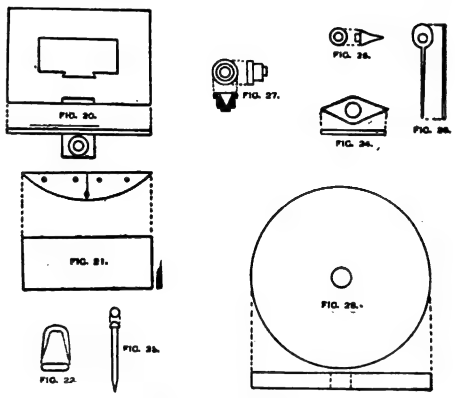
If a man constructs one box he is pretty sure to at least partly construct several others for his friends; then the templets will come in exceedingly handy. A word of caution: Do not try to use vulcanite fibre; insist upon obtaining a nice flat piece of hard rubber. A friend of mine attempted to make a vulcanite base-board; he found the material was not flat; one end or one corner would be twisted up and no matter how long the material was pressed flat, it would curl up under the next change in the atmosphere. Vulcanite fibre can easily be put into any desired shape, as it becomes very soft when placed in boiling water for a short time; hard rubber can also be treated in the same manner, with the difference that while the rubber will stay in place, the vulcanite fibre insists upon curling up worse than a piece of green gum wood.

The base-board satisfactorily finished, the next step is to make the contact strips shown by Fig. 4. Four of these will be needed for units, tens, hundreds and thousands. The studs may be soldered in, or they may be tapped and screwed; the former method was used in the instrument at hand. Fig. 7 shows one of the contact pieces, fifty-two or fifty-three of which will be needed; the extension to the right is simply for convenience in soldering on the wire of the resistance coils. By prolonging the shank as in the illustration, there is no need of reaching down with the soldering copper to the threaded portion.

Fig. 8 shows the contact sockets used not only for the resistance coils in the battery circuit, but for connecting the battery upon the base-board of the instrument. A couple of these pieces are also used as contact surfaces to close the keys upon, so that fifteen of them will be necessary. The nuts are all of one size, both for the contacts (Fig. 7), the contact strips (Fig. 4), and the multiplying and dividing bars (Figs. 12 and 13); therefore of the nuts (Fig. 9), seventy-six will be required. These had best be purchased, either finished, blank or tapped to some convenient thread; then the studs may be all threaded to fit the nuts.

Figs. 10 and 11 merely represent the two parts of the binding posts used for connecting in the object to be measured; four of these will be needed; two as regular binding posts and two as parts of the keys, one of the springs of which is shown at Fig. 14; the hard-rubber thumb-pieces of the keys are shown at Fig. 15; Figs. 12 and 13 show the multiplying and dividing bars; they may be made precisely alike, except they must be in pairs, one right-, the other left-handed.

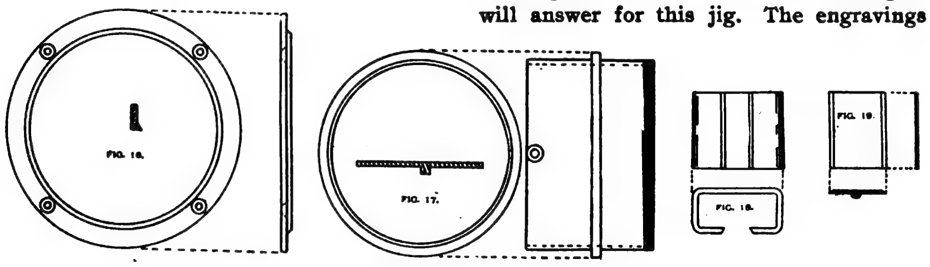
There are several ways of making the multiplying and dividing bars (Figs. 12 and 13) and contact strips (Fig. 4). They may



FIGS. 20 TO 28.

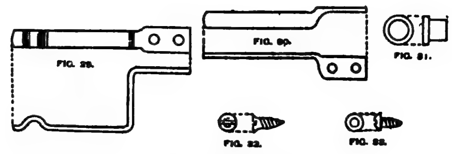
be marked out and the holes cut in with a rat-tail file. This is not a good method when a considerable degree of exactness is required, especially when more than one box is to be made, or provision made for the possible construction of duplicates. The jig shown by Fig. 5 is easy to make, costs little, and will enable a man to make both the strips (Fig. 4) and the round contacts (Fig. 7).

Two pieces of iron, either cast or wrought, will answer for this jig. The engravings show the whole matter so plainly that little description is necessary. The brass contact-strips may be spaced off by marking through the templet used for laying out the rubber base-board. Each mark on the contact-strip is to be brought out in turn to the mark, *a* (Fig. 5), the jig clamped and the drill run through in that position.



FIGS. 16 TO 19.

Both pieces (Figs. 4 and 7) can be drilled at the same time if desired, but it may be well to drill one at a time. Fig. 7 is put in through the slot, shown in both Figs. 5 and 6. The counterbore, *b* (Fig. 6), holds the



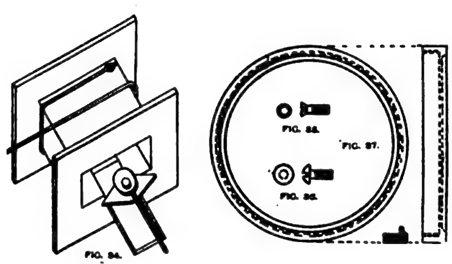
FIGS. 29 TO 33.

round piece in place while it is being drilled. The washer, *c*, serves as a distance-piece to keep the parts of the jig the right distance apart. It can be placed upon either pin, as required.

For making one box, and possibly for two, the jig will stand for drilling without bushing the holes, but for making a number of boxes, the drill holes should be fitted with steel bushings. The hole, *d*, is for the purpose of removing any chips that may chance to work into the jig. The hole, *e*, is for making the pin-hole on the ends of the multiplying and dividing contact-pieces (Figs. 12 and 13.

The keys (Fig. 15) may be made of hard rubber, and two pieces will be required. They should be drilled and tapped to receive a common machine screw, the head of the screw forming the contact part of the key.

The galvanometer case must be the next to receive attention. It is shown by Fig. 17, and the flange which secures it to the base-board is represented by Fig. 16. Elevations of these plans are given at the right, and sections of both are shown inside of the circles. To make the galvanometer box shell (Fig. 17) it may be cheaper to make a little pattern and have a casting made therefrom, which may be turned up to the required shape. Originally it was intended to bend



FIGS. 34 TO 37.

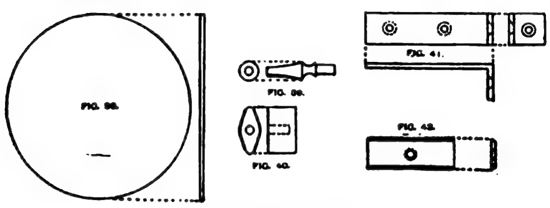
up and solder a piece of sheet brass, then to solder on the square ring which supports the box upon the base-board. Upon further thought it was decided that the pattern and casting method would be preferable, and so it proved during construction.

A portion of the galvanometer box is shown by Fig. 18, this may be bent up from a piece of sheet brass and finished to the shape or size indicated by the drawing and its accompanying figures. This piece may be shaped by bending it around a piece of bar iron of the right size to fill the inside of the brass piece. The ends of the strip thus formed must be beveled to an angle of 30 degs., and cut back so as to be one-half inch apart when finished. Fig. 42 fits into the space thus left between the ends of

Fig. 18 and 19. A plain piece of brass is to be fitted over the notch left in 18, so as to cover the gap between the ends. The piece fits between the ends or heads of galvanometer box (Fig. 20).

The needle pivot (Fig. 25) is fastened into 42 and it is made in this form in order that the pivot and needle may be easily withdrawn from the galvanometer box by pulling it out of its seat, the method of doing being plainly shown in Fig. 34, as also is the general form of the galvanometer box.

Fig. 21 is a piece of plain pine wood; this is sawn out on the jig-saw to the shape shown, and a piece of white paper glued on top as marked with the o, a straight line shown upon the circular segment. The pointer or index of the galvanometer is to be brought to coincide with the o mark



FIGS. 38 TO 42.

upon this paper-covered bit of wood (Fig. 21). A double-pointed carpet tack (Fig. 22) is pressed into two holes near the o mark (Fig. 21), and the pointer of the galvanometer needle is placed underneath this double-pointed carpet tack. The tack prevents the needle from moving very far from the o mark; a pair of round-headed nails (Fig. 23) are driven into the remaining holes in the segment (Fig. 21), and serve to fasten this bit of wood down upon the bottom of the galvanometer box (Fig. 28) which is made of hard rubber, as before stated.

One end of the galvanometer box is shown in Fig. 20, also the method of fastening same down to the bottom of the circular shell, the projecting bit of brass being soldered to the heads of galvanometer box. Two of Fig. 20 will be needed, one for either end of the box.

Two ways of making the ends of the box (Fig. 20) are open to the maker. He may cut the opening in ends large enough to go over the central part already described (Fig. 18), or the hole in each end may be made same size as opening through Fig. 18. Then, in soldering, the central part and both ends or heads may be placed upon the piece of bar iron, around which Fig. 18 was shaped. A piece of wire twisted around the box center will keep it in shape and in place during the soldering operation.

If the first method is used, no core will be needed, the heads keeping the central core or shell in place until soldered. The former method makes the best-looking job, because there is no joint all around opening in box-heads or ends.

Figs. 25, 26 and 27 show the parts of the pivot, pointer and center upon which the needle swings. Fig. 27 is perhaps the best piece in the whole instrument; it is also one of the worst to make; that is, to get it just right. After vainly attempting to make the conical hole smooth enough so that the pivot would swing easily inside of it, I gave up the matter as a bad job; drilled a conical hole completely through the brass and cast about for something to use in the place of a jewel for the pivot to bear against. Probably it would be cheapest and best in the end for the machinist to take the little bit of brass (Fig. 27) to a watchmaker and have him set a real jewel therein; but the writer, not having any jewels to spare for measuring instruments, constructed a substitute from a piece of glass tubing. A piece of lead glass about ⅛ in. in external diameter was heated in an alcohol lamp and drawn down to a point; in other words, the piece of softened glass rod was pulled apart and so manipulated that it tapered from full size to nothing in about $\frac{3}{16}$ or ¼ in.

After drawing down the rod and breaking it apart, the small end of one of the cones thus formed was heated in the lamp, and as it became melted, the glass shortened up and assumed an approximately globular form. This gave just the required shape to the inside of the glass cone, forming a very acceptable jewel, which was fastened into Fig. 27 by means of a little shellac.

The pointer (Fig. 26) is made of aluminum. It can be hammered out cold, as that metal is very ductile, and flows well under the hammer without breaking. It will be noticed that one end of the pointer is made short and broad. This amount of metal is necessary in order to have the pointer balance well, and there must be more metal in the wide counter-balance part, than in the pointer end. This is owing to part of the pointer being located farther from the pivot than is the metal forming the counter-balance. The best way to make this right, is to work out the pointer to the exact shape desired as shown by Fig. 26, leaving the counter-balance end larger than shown by the drawing, then file down that part until the needle and pivot balance satisfactorily.

The needle (Fig. 24) should be made of the best tool steel available. It should be finished to size and then hardened. The temper must not be drawn, as the harder the steel the better it will hold the magnetism. The needle being very hard, as stated, care must be taken in putting the center (Fig. 27) in place, for if it is forced or driven very hard, there will be danger of breaking the needle. If the needle be balanced ever so carefully before magnetizing, it will not hang level after that process has been gone through with; as the north-seeking pole of a needle always rises, and must be weighted to make it lie level. The needle used in this instrument is so short that the variation in level will be but slight, and may be easily corrected by grinding a little off of the south end of it. In long needles, a fine wire is usually bent around the north end, and the needle balanced by sliding the weight thus formed, to or from the center of needle. When the north end of a compass needle begins to hang a little low, it is a pretty sure sign that the magnetism is getting weak, and should be renewed.

The magnet (Fig. 24) should be short, not over twice its width in length. A long, slim magnet does not work well in a galvanometer; for the reason why the reader is referred to text books and other electrical authorities. A pair of contact-pieces (Figs. 29 and 30) are bent up from plain, flat brass, as shown. These contact-pieces are simply for making connection with the galvanometer winding. It is necessary that the circular galvanometer shall be so constructed that it can be revolved in order to bring the compass needle parallel with the earth's magnetic meridian. Contact piece 29 bears upon the brass plug, 31, which is inserted in the bottom of galvanometer case, being pressed in the hole shown in Fig. 28. This contact piece being axial, of course, the box may be revolved to any extent without destroying the contact.

Spring 30 bears upon the outside of the circular galvanometer case (Fig. 17); this also permits the case to be turned completely around without affecting any of the electrical contacts. Half a dozen screws, four of the kind shown by Fig. 33, and two flat-headed screws (Fig. 32) will be required; these, of course, should be purchased. The bottom of galvanometer case (Fig. 28) has already been described; it may best be constructed of hard rubber, as before described. Fig. 34 shows the method of assembling the galvanometer box; it also shows one coil of the wire, one end of which is soldered to the case, then the rest is wound on between the brass heads of the box. The amount of wire to be placed upon the galvanometer may be varied according to the kind of instrument desired; that point will be decided later, or the electrical man may figure it out for himself.

Some more screws are shown in Figs. 35 and 36; four of each will be required, and they are used for fastening down the galvanometer case, and for fastening the hard-rubber bottom into the brass shell (Fig. 17). Fig. 37 gives the shape and character of the cap necessary to close the galvanometer case. The piece of glass (Fig. 38) may be cut out with a wooden pattern and an ordinary wheel glass cutter; it can also be shaped in a number of ways; the one given, however, is probably the most simple. The plugs required for plugging in and out resistances are shown by Fig. 39. Six of these will be required for the ordinary instrument, but eight will be necessary where the central contact is used, as it is in the instrument here described. The hard-rubber parts or handles of the plugs (Fig. 40) may be dressed out very quickly by means of a file and a small vise; clamp the rubber in the vise right down to the jaws. I found this to be the quickest way of cutting out the rubber pieces after they were first cut up by means of the circular saw. Eight pieces of brass must be made as shown by Fig. 41; these pieces are for holding the wooden reels in place.

How to wind and set up this instrument, including the making of an oak box for it, will be described in a succeeding issue under the title of "Winding and Adjusting a Testing Set."

Resistance Wires.

Copper alloyed with 30 per cent. of manganese is said to have a resistance 60 times greater than pure copper, and more than three times greater than German silver. Manganese steel has a resistance of forty-eight times greater than copper.

AMERICAN TELEPHONE PRACTICE.

BY KEMPSTER B. MILLER.

SWITCH-BOARD FOR METALLIC-CIRCUIT LINES.

To avoid induction and other sources of trouble, metallic-circuits are rapidly superseding ground circuits in telephone exchanges. The switch-boards in common use for metallic-circuit exchanges are built on the same general principles as those for grounded circuits described in the last article, differing from them only in such details as to render possible the connections of the two branches of one line with those of another line through the cord circuits. For this purpose two separate contacts are provided in each jack forming the terminals of the two branches of the line. The plugs also have two separate contact-pieces adapted to register with the contact-pieces in the jack when a connection is made. Each contact on the plug is connected to a similar contact on the other plug of a pair through the medium of a double-conductor flexible cord.

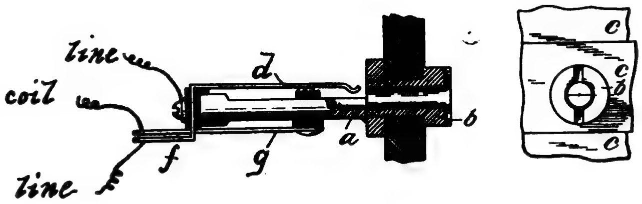


FIG. 1.—METALLIC-CIRCUIT JACK.

One form of metallic-circuit jack is shown in Fig. 1. Here the tubular portion, *a b*, forms a terminal for one side of the line, while the flexible spring, *d*, forms the terminal for the other side of the line. The terminal, *g*, connected with the pin upon which the spring, *d*, normally rests, forms one terminal for the coil of the line drop. The other terminal of this coil is attached to the terminal, *a*, so that when the spring, *d*, is in contact with its pin the circuit is complete from one side of the line to the other through the drop coil. The tubular frame of this jack is made in two pieces, *a* and *b*. The front portion, *b*, is a hollow screw threaded to engage a tapped hole in the front of the piece, *a*. By this arrangement any jack may be readily removed from the board by unscrewing the piece, *b*, until it disengages the rear portion, *a*. A slot for receiving a screw-driver is provided on the front of the piece, *b*, to accomplish this.

A metallic-circuit plug in common use is shown in Fig. 2. The tip conductor is

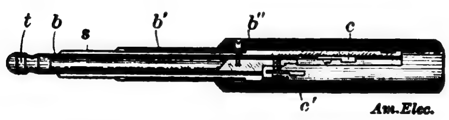


FIG. 2.—METALLIC-CIRCUIT PLUG.

formed of a rod of brass slightly enlarged at its forward end. This is encased in a bushing, *b*, of hard rubber, and over this is slid a tube, *s*, of brass forming the sleeve of the plug. A second bushing, *b′*, covers the rear portion of the sleeve, *s*, and the rear portion of this latter tube is in turn covered by the tube, *b″*, of hard rubber, forming the handle of the plug. The tube, *s*, forming the sleeve has a portion which projects rearwardly into the handle and is there provided with a connector, *c*, to which the terminal of one conductor of the flexible cord is attached. The other connector, *c′*, is attached to the rear portion of the tip piece, *t*, and forms the terminal for the other conductor of the cord.

In Fig. 3 is shown in diagrammatic form the circuits of a switch-board of this class. Here the line wires, l^1 and l^2, forming the two sides of a metallic circuit, enter the spring jacks, *e*, e^1 and e^2, in the manner described in connection with Fig. 1. It will be noticed that while the tip spring, *d*, is in its normal position, circuit is traced from the line, l^1 through the coil of the drop, *f*, and back to line, l^2, so that current sent from the subscriber's station will actuate the drop, thus indicating a call. When one of the plugs, *P* or *P′*, is inserted into the jack spring, *d* is raised from its normal resting

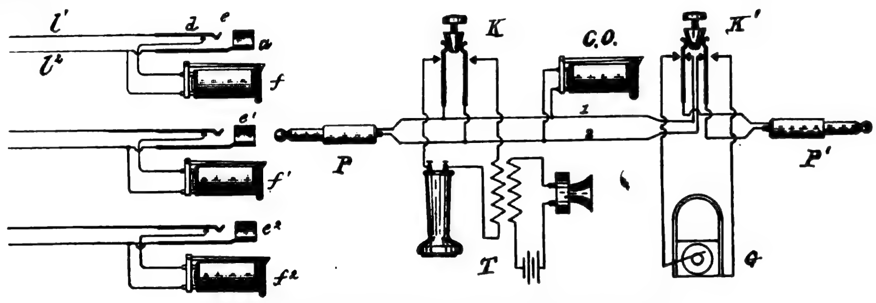


FIG. 3.—CIRCUITS OF METALLIC SWITCHBOARD.

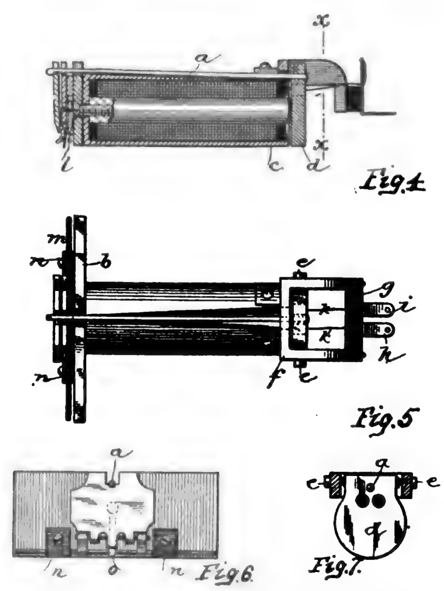
place and breaks contact with the terminal leading to the drop coil, thus cutting the drop out of the circuit. At the same time, the connection is continued from the two line wires. l^1 and l^2; to the two strands of the cord circuit. When an operator notices that a drop has fallen she inserts the answering plug, *P*, into the jack corresponding to that drop and by pressing the button, *K*, belonging to that cord circuit, bridges her telephone set, *T*, across the two strands, 1 and 2, of the cord circuit. This enables her to communicate with subscriber calling to ascertain his wants. She then inserts the calling plug, *P′*, into the jack of the called subscriber and presses the button *K′*, thus connecting the terminals of the generator, *G*, with the two sides of the line of the subscriber called.

It will be noticed that when the key, *K′*, is in its normal position the conductor from the tip of the answering plug to the tip of the calling plug is made continuous by the spring, 3, of the calling key resting against the anvil, 4; similarly the conductor between the sleeves of the two plugs is made continuous by the spring, 5, of the calling key, making contact with the anvil, 6. When the key is depressed the springs, 3 and 5, break contact with the anvils, 4 and 6, thus severing the connection between plugs, *P* and *P′*, and immediately afterwards connect with the anvils forming the terminals of the generator, *G*, thus sending current over the called subscriber's line.

The clearing-out drop, *C O*, is permanently bridged across the cord circuit as shown, in order to indicate to the operator when either subscriber rings off. In order that the efficiency in talking may not be impaired, this drop is made of high resistance and high impedance.

The line-drops are usually of the ordinary type described in connection with the grounded-circuit switch-board. The clearing-out drops, however, must be made to meet more difficult requirements. As they are always bridged across the circuit of two connected subscribers, it is found that unless special precautions are taken much trouble will be experienced from cross-talk due to induction between two adjacent drops. This difficulty cannot be overcome as in the line-drops by cutting them out of the circuit whenever two subscribers are connected, inasmuch as the very purpose for which they exist requires them to be always in such circuits. Neither can it be overcome by placing the drops at such a distance from one another that this induction will not be felt, for the limited space on switch-boards requires that they be put as close together as mechanical conditions will allow.

It has thus been found necessary to design drops which would neither affect nor be affected by any similar drop in its immediate vicinity. This has been accomplished in several ways, but the best example is that shown in Figs. 4, 5, 6 and 7, which illustrate what is known as the "Warner



FIGS. 4, 5, 6 AND 7.—WARNER DROP.

Drop." In this the coil is wound in an ordinary manner on a soft-iron core and is then encased in a tubular shield, *c*, also of soft iron. The armature, *d*, is pivoted at points, *e*, in a bracket, *f*, mounted directly on the rear portion of the tubular magnet.

From this armature a rod, *a*, extends forward through a notch in the front plate, *b*, in such manner as to engage the upper portion of the shutter and thus hold it in its raised position. A screw, *l*, passing through the front plate, *b*, serves not only to hold the magnet in place, but to hold the core in its place within the shell. The terminals of the coil are led out through two small holes in the armature and are connected with the terminals, *h*, *i*, mounted on an insulating strip, carried on the bracket, *f*.

These drops should be so nicely made that the armature, *d*, will fit closely against the end of the tube, *c*, in such manner as to almost completely close the magnetic circuit in which the coil is placed. The lines of force generated by the passage of a current through the coil follow almost entirely the path provided for them by the shell and the core of the magnet, thus not only producing a very efficient electro-magnet, but also preventing any of the lines of force from extending beyond the limits of the shell. These drops are usually wound to a resistance of 500 ohms and may be mounted as closely together as desired without producing any serious cross-talk. The impedance due to the great number of turns in the coil and to the perfect magnetic circuit surrounding the same, is so great that practically no diminution in the strength of speech transmission is felt due to its being bridged across the two sides of the line.

INTERIOR WIRING.

TESTING THE PLANT FOR ACCEPTANCE.

The subject of this section is the last operation in the installation of interior wiring and one of the most important.

The circuits should be tested for continuity, short circuit, resistance and insulation. The tap circuits should be tested by a magneto bell for continuity and insulation resistance before they are connected to the feeders, thereby perchance saving much subsequent search for faults, and perhaps the tearing up of walls to remedy them. But after the job is complete and the circuits are all connected a general final test will undoubtedly be made by the consulting engineer in charge, and should therefore be anticipated by the contractor.

It is most convenient to test after the power has been turned into the system, for then the working pressure is on the circuits and the only necessary instrument is a good double-scale voltmeter. The lamps themselves show the continuity of the circuits by the fact that they burn, and persistent refusal to do so shows a short or open circuit on that part of the system on which they may be placed.

This being the case, disconnect the faulty circuit at the fuse box and turn off all its lamps. Then trial with a magneto across the terminals resulting in a ring shows short-circuit, while silence proclaims open circuit; indeed, if short-circuit is the fault, it will without doubt be plainly made evident at a fuse.

Open circuit should be sought for at the joints, either in the fuse box or the fixtures, for there is little likelihood, in comparison, of a fault in the straight runs of wire connecting the outlets. Disconnect the fixtures from the terminals and ring from the fuse box. If the fault is open circuit, connect the terminals that were connected to the fixture together, and if the bell rings that shows that the trouble is in the fixture. Similarly, if a short-circuit is the trouble, silence of the magneto on disconnecting the fixture indicates that the trouble is in the latter.

If thorough tests locate the trouble in the line, and the latter is on the conduit or concealed system, the wires will have to be drawn out. On open work the fault can usually be located by inspection. Cleat and knob work within the walls necessitates tearing the latter open.

A very common fault is due to the ignorance of wiremen or helpers, and is shown in Fig. 1. The man gets an idea that unless the free ends of a circuit such as *a* and *b*, are connected, it will be inoperative, and many amusing reasons have been given, among them that the electricity would leak out at the free ends or that unless they were connected the circuit would be open. This fault is, of course, a dead short-circuit. It seems almost too childish an error to speak of in such an article as this, but its persistent commission by many different individuals in

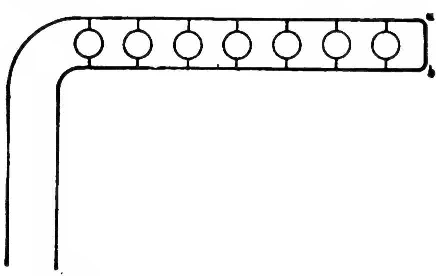


FIG 1.—A SHORT-CIRCUITED LINE.

the experience of the writer prompts him to mention it.

A ground is a more frequent occurrence than a short-circuit in a line of wiring, because only one thickness of insulation is broken down instead of two. If the ground is in the fixture—and it is more likely to be there than anywhere else—that fact will be betrayed by its disappearance on the disconnection of the fixture from the line. If, however, the ground is in the line, it should be sought for with the voltmeter when the current is on. Connect one terminal of a voltmeter to the gas pipe or other good ground connection, and try the other end on either line wire. The side that gives a large deflection is the one that is clear. Connect between this side and the ground an incandescent lamp. If it comes up to full candle power, the fault is probably a dead ground, but if it is only a partial one, the lamp will burn dimly.

Connection between the ground and the grounded side with a voltmeter will now show a small deflection. Continue to test the grounded side in this way at different points till a place is found where the deflection disappears altogether. This is the grounded point, and the fault will probably be apparent on inspection. It is convenient to proceed along the circuit testing at intervals and noting the deflections which grow smaller as the ground is approached. After the ground is passed, the deflections will begin to grow larger again. Therefore an increase in deflection is pretty conclusive evidence that the ground is between this point and the last one tested, although it might be due to the fact that the ground suddenly became more pronounced.

The insurance rules demand that circuits having the following capacities have the corresponding insulation resistances given. Cut-outs and safety devices should be in place, but if lamp sockets, receptacles, fixtures, etc., are connected, only one-half the insulation given will be required.

Up to	5	amperes	. . . . .	4,000,000 ohms.
"	10	"	. . . . .	2,000,000 "
"	25	"	. . . . .	800,000 "
"	50	"	. . . . .	400,000 "
"	100	"	. . . . .	200,000 "
"	200	"	. . . . .	100,000 "
"	400	"	. . . . .	50,000 "
"	800	"	. . . . .	25,000 "
"	1600	"	and over	12,500 "

The wiring contractor, however, should not be satisfied with such low insulation resistances as these. A 2000-light plant wired on cleats and knobs should have an insulation resistance of at least one-quarter megohm, and unless the quality of the insulation is very poor, a lesser amount than that will probably be due to a local defect in one of the circuits. A conduit job of the same size should test out at least 100,000 ohms. Separating the sub-circuits one by one from the system, a sudden restoration of the insulation resistance to its proper value locates the circuit on which this local defect exists.

Another point which it is important to test for is the resistance of the circuits. Of course, it is to be supposed that calculation has been applied, and if the work has been properly done and the copper is of good quality, these calculations will be verified; but if bad joints, poor copper, or wire that is too small has been incorporated into the system, the tests will show a greater wire resistance than should be permitted. A common way to test for drop is to take the voltage at the dynamo and then carry the voltmeter to some distant lamp and take the voltage there. If the conditions remain exactly the same during the test, this would be a good method, but unfortunately the dynamo voltage is liable to change, and some very astonishing results, such as finding a higher voltage at the distant lamp than at the dynamo, are liable to be obtained. Indeed, the writer has known engineers of isolated plants and even of central stations to declare that there was no drop of voltage on their lines, basing their assertion on tests made after this fashion, which are obviously utterly worthless.

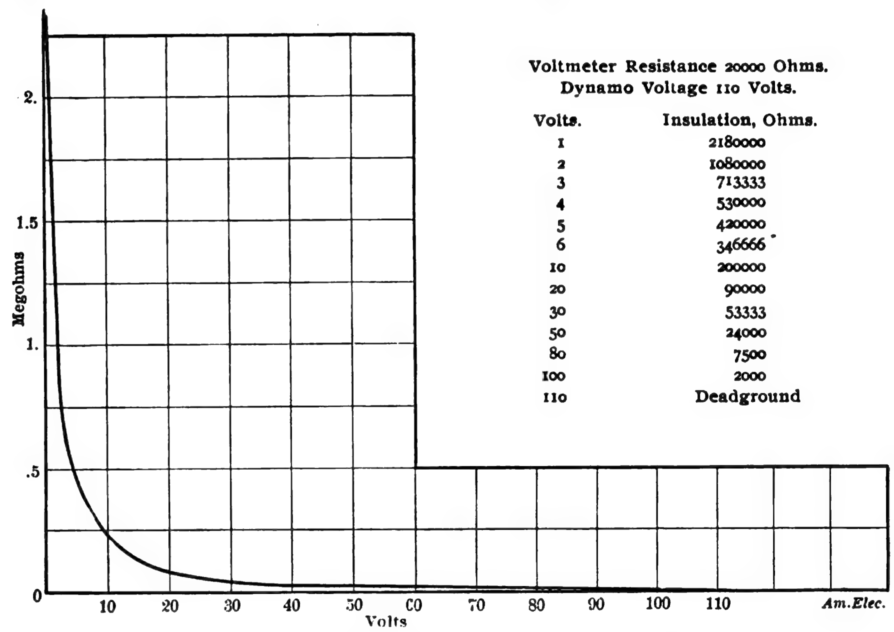
One of the most convenient ways is to disconnect the circuit to be tested from the mains, short-circuit its further extremity and measure its resistance with a Wheatstone bridge. The result should check the computed resistance to within a few per cent. Another way which is valuable on circuits of many branches is to select a wire of a single circuit which leads to the dynamo room and disconnect it entirely from the system and connect the end in the dynamo room to the positive bus-bar. Connect one wire of a low-reading voltmeter to it at the distant point where lamps are to be

tested, and apply the other wire of the voltmeter to the positive lamp terminal. The resulting deflection should be half the computed drop. Care should be taken not to apply the free voltmeter terminal to a negative terminal of the lamps, for that would be placing a low-scale instrument across a comparatively high potential, and would probably result in a burn-out. It will be better to make a preliminary test as to which is the negative terminal with the higher scale of the instrument.

The measurement of insulation resistance may, of course, be made with a Wheatstone bridge, but it is preferably made with a voltmeter, and perhaps it will be well in closing to repeat the time-honored method which is used, for it may not be familiar to some who have endeavored to obtain knowledge of interior wiring from this series of articles.

Let the insulation resistance to be determined be designated by R, the voltmeter resistance by R_1; this latter quantity will usually be given on the inside of the case that carries the instrument. Let the dynamo potential be V. The test is made by connecting the dynamo potential in series with the voltmeter and the insulation resistance to be tested, and noting the resulting deflection, which we will call V_1. The insulation resistance is then given by the formula $R = \frac{(V - V_1)\ R_1}{V_1}$.

If we can consider the dynamo potential a constant quantity, it is obvious that every voltmeter deflection obtained in this way corresponds to a certain insulation resistance. Unfortunately, V_1 is not a simple factor function of R, and therefore, in order to make a convenient reference, recourse must be had to a curve in which the insulation resistance for given deflections is plotted with reference to the deflection. By reference to this curve, an example of which is shown in Fig. 2, any voltmeter deflection can be quickly interpreted.



Voltmeter Resistance 20000 Ohms.
Dynamo Voltage 110 Volts.

Volts.	Insulation, Ohms.
1	2180000
2	1080000
3	713333
4	530000
5	420000
6	346666
10	200000
20	90000
30	53333
50	24000
80	7500
100	2000
110	Deadground

FIG. 2.—CURVE OF INSULATION RESISTANCE.

Resistance of Acidulated Water.

A column of water acidulated by sulphuric acid has a resistance 1,000,000 times greater than a copper bar of same dimensions.

TESTING DYNAMOS.

THE STRAY-POWER METHOD.

In a previous article it was mentioned that all of the losses of a dynamo, with the exception of the wire losses, may be classed together, and these are often called the stray power. The assumption is made that the stray power is a constant quantity whatever the load, provided that the speed and armature voltage remain the same. This is not strictly true, but is as nearly so as any other assumption that could be made and is accurate to a few per cent.

The stray-power method of testing for efficiency is one of the most convenient methods that can be used, for the reason that nothing is necessary but a good ammeter, a double-scale voltmeter and a source of current of the same kind that the machine supplies when running as a dynamo. The machine is run as a motor, the connections being made as in Fig. 1. The proper speed is obtained by varying R_1 and the proper voltage by varying R_2.

Before the test begins the machine must be hot from carrying a long-continued load. The resistance of the armature should then be measured by passing through it as large a current as it will conveniently carry, the fields being unexcited, and taking the drop of potential from brush to brush by means of a low-scale voltmeter. This potential divided by the current will be the resistance of the armature, which we will designate by R. The resistance of the field magnet should be similarly obtained, but in this case the voltage will be a very much larger quantity and the current considerably less. Let this resistance be denoted by R_f.

These factors having been determined, the machine is started as a motor running empty, an ammeter and a voltmeter being placed in the armature circuit. The current in the field circuit is of no import, so that it is adjusted to give the machine the same speed as a motor as when it is running under full load as a dynamo. Speed and load having been accurately determined, a number of readings of the voltmeter and ammeter in the armature circuit are taken. The product of the averages of these two readings is equal to the stray power, plus the heating losses of the armature at no load.

These latter losses must be calculated and subtracted. To do this, take the square of the average current and multiply it by the resistance of the armature; subtracting this from the product of the average current and average voltage, the result will be the stray power. It is customary to assume that the stray power is proportional to the speed and to the armature voltage.

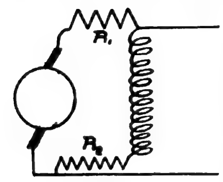


FIG. 1.

The efficiency of the machine is its output divided by its input or the output divided by the output plus the losses. The output of the machine can readily be measured by the product of the ammeter and voltmeter readings at full load, and the losses can now all be calculated, therefore the following formula holds:

$$p = \frac{VC}{VC + C_a^2 R_a + C_f^2 R_f + S}$$

the letters having the following significance.

p = commercial efficiency.

C = current delivered by dynamo at full load = $C_a + C_f$.

V = dynamo voltage at full load.

C_a = armature current at full load.

C_f = field current at full load.

R_a = armature resistance.

R_f = field resistance.

S = stray power.

It is customary to assume that the stray power is proportional to the speed and the armature voltage.

This method is applicable to any direct-current dynamo except those of the open-coil, arc type, which do not operate well as motors, in fact, any arc machine is hardly suitable for such a test for the reason that the design and operation are so peculiar that the assumptions as regards stray power do not hold.

In the case of compound machines the resistances of the series coil and armature should be measured together. When run as a motor to test for the stray power, the ammeter should be connected to the armature circuit in such a way that it does not measure a current for the shunt field. The combined resistance of the series coil and armature may be considered as the resistance of the armature, and the previous formula applied. It will probably be best to cross the shunt-field terminals when running the machine as a motor, for the reason that if this is not done the series and the shunt coil will oppose each other, and it may require an excessive current in the shunt field to bring the machine speed down to its rated value.

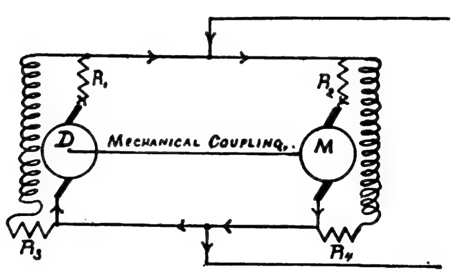


FIG. 2.

A rough modification of the stray-power method is used by some makers, and consists simply in running the machine as a motor at the rated speed and assuming that the watts necessary to do this work are the losses of the machine—a sort of friction-load card of the dynamo, but by no means as accurate and representative as the steam engine analogue. This quantity is less than the true losses of the machine by the difference between C^2R losses at no load and at full load, and although it gives an idea of the general efficiency of the machine to those who can make allowances, and on account of the ease of obtaining it it is very convenient, yet it has been paraded before purchasers as representing the true efficiency of the machine in order to make a sale.

Another and very satisfactory method in which to apply the stray-power method of testing is sometimes used to test railway motors, but requires two similar machines. It is, strictly speaking, a combination of the Hopkinson electrical method and the stray-power method. The two machines are coupled together so as to run at the same speed, preferably by direct connection, but if that is convenient a belt may be used. The machines are connected together as shown in Fig. 2. Now if one of these machines receives current from an outside source and is thereby driven as a motor, it will drive its mate as a dynamo which will in turn generate current and deliver it to the motor; it therefore follows that whatever current is supplied from the outside to feed the combination, multiplied by the voltage at which it is delivered, represents the losses of two dynamos, and if accurately measured, will afford the necessary factor for computing the efficiency. The motor carries the current that the dynamo gives it and also the current from outside, and therefore if the dynamo is fully loaded, the motor will have to be slightly overloaded in order to drive it, and this inequality of load makes it unfair to divide the resulting losses of the test equally. This may be corrected by taking the C^2R, losses of both machines at full load. Subtract this from the watts supplied from outside and the result will be twice the stray power of two machines. Then apply the stray-power formula.

It may be asked how it may be determined which machine is dynamo and which motor. This can not only be determined but controlled as well. The machine having the weaker field will be the motor, and the load can be accurately adjusted by varying the motor field rheostat. The speed of the two machines being the same and the armature voltage also being the same, the stray power is a constant quantity and the method of allowing for the difference in C^2R losses has been explained.

A number of precautions must be observed in making this test. The machines must be run at full load for several hours, and gotten thoroughly warm, and in this condition the resistance of their circuits must be measured.

The system should be started as follows: The armature circuits of both machines should be open, and the current turned on from outside, thus exciting the fields of both machines. Then current should be slowly turned into the motor by manipulating the resistance, R, and the combination will start and will soon attain the proper speed. Then the dynamo voltage should be adjusted and the machine thrown in in precisely the same way as would be employed in connecting it on to the bus-bars of a central station. R_1 should not be used on the dynamo circuit, but connection should be directly made at once after the proper voltage is attained. The moment connection is made the ammeter in the dynamo armature circuit should be consulted and the load adjusted to the proper value by adjusting R_3 or R_4. Strengthening the dynamo field or weakening the motor field increases the load, or *vice versa*. The brushes should be adjusted once and for all, for adjustment during the test produces change in armature voltage that may cause the exchange of

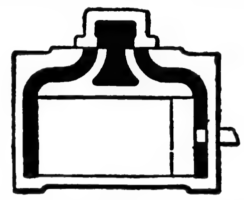


FIG. 1.—PLAIN SLIDE VALVE.

dangerous currents between the machines before their field rheostats can be adjusted.

Series motors cannot be tested on this plan unless some changes are made in the connections on account of the instability of the series dynamo in multiple with a constant-potential circuit. To this end the fields must be disconnected altogether and separately excited and the armatures connected in multiple and tested, as in Fig. 2. The exciting current does not enter into the calculations, but it is important that it should have the same value as the current in the motor armature, in order that the field strength shall be the same as would occur in practice.

It is to be noted that the field of a series motor varies with the load and therefore the

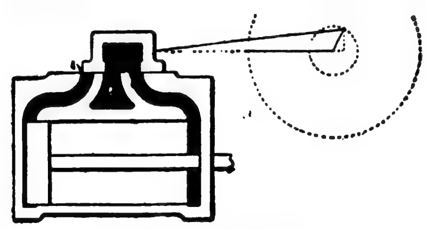


FIG. 2.—ADMISSION.

stray power is not a constant quantity at all loads, and must be determined at the load at which the efficiency of the machine is desired to be known. It is therefore evident that the simpler stray-power method of running as a motor on no load is not applicable.

Primary Batteries.

The porous cup form of Lelanché battery has an E. M. F. of 1.48 volts. For each pint charge a cell has a theoretical capacity of 65 ampere-hours, 86 watt-hours or .11 HP-hours. In a cell having an E. M. F. of 1.5 volts, 1.78 lbs. of zinc will be consumed for each KW-hour of energy produced at perfect efficiency, including energy used in cell. Working at maximum power (internal resistance=external resistance) the consumption will be 3.56 lbs. of zinc, and with 80 per cent. efficiency this becomes 4.4 lbs. per KW-hour or 3.3 lbs. per HP-hour.

SLIDE VALVES.

There are so many ways of getting steam into a cylinder, and of distributing it as it is admitted, that a comparison of the several methods employed by various engine build-

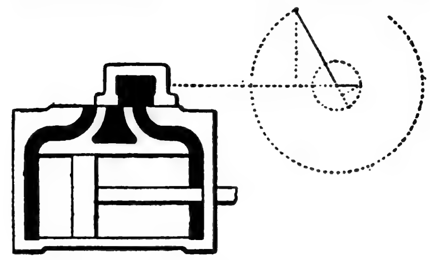


FIG. 3.—END OF VALVE TRAVEL.

ers, will be valuable to the man who wishes to know all that can be learned of steam and its use.

The different valves described will not be mentioned by the names of their makers; a number will be given to each, and during the discussion, will be referred to by that number alone. Some valves will be recognized at once, others will require considerable study before their ownership becomes apparent. In succeeding issues the peculiarities and mode of action of piston valves, also those of a rotary type, such as the

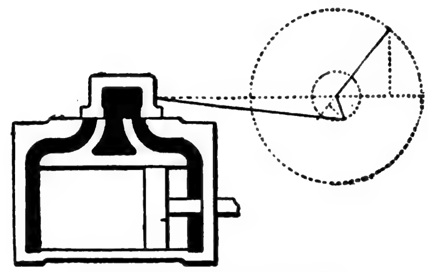


FIG. 4.—STEAM CUT-OFF.

Corliss, etc., will be described, with accompanying engravings.

The plain slide valve (Fig. 1) is the most common type of valve, particularly in low-grade engines, although some of the most efficient engines in the market are fitted with this form of valve. Fig. 1 shows some of the things designers have to contend with in adapting the slide valve to their particular needs. The projection of the ends of the valve beyond the outer edges of the ports, known as "lap," requires a proportion of exhaust port and bridge width which will not allow the exhaust port to be too much contracted when the valve is at its greatest throw. Fig. 3 shows this contraction.

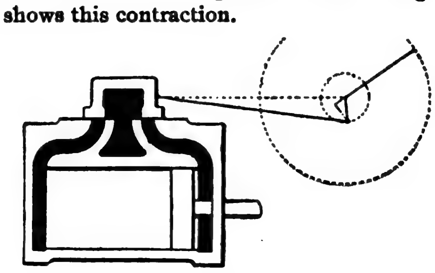


FIG. 5.—COMPRESSION.

In Fig. 2 the position of a slide valve is shown as the crank is passing the dead center next to the cylinder. The valve has started to open and is admitting steam at *a*. The steam in the other end of the cylinder is free to pass into the central exhaust pass-

age, *e*. In Fig. 3 the valve has reached the end of its travel, and the port is fully opened, the crank having made about one-sixth of a complete revolution, or one-third of a stroke.

Here the limitations of the slide valves

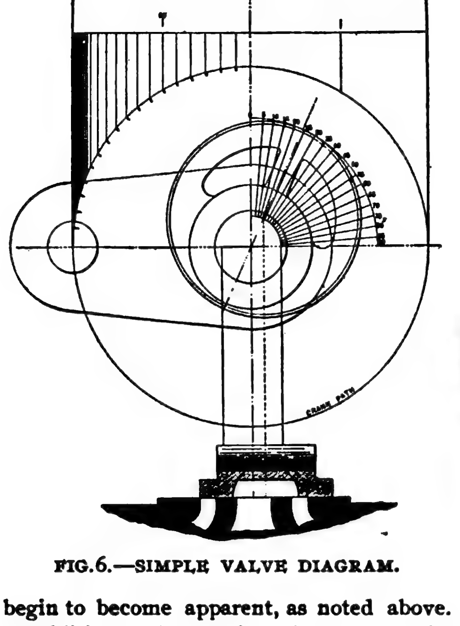


FIG. 6.—SIMPLE VALVE DIAGRAM.

begin to become apparent, as noted above. In addition to the choking of the exhaust by a great travel of the valve, there is a limit in the other direction, for if the valve is not given sufficient travel, it cannot open the steam ports fully, as will be seen by a study of these engravings. In Fig. 4, the valve has traveled to the left until the steam supply has been cut off, and the remainder of the stroke has to be driven by expansion of the steam contained in the cylinder.

Fig. 5 shows the exhaust valve closed, so that compression can begin in the exhaust steam remaining in the cylinder, and the problem is to compress the exhaust steam up to nearly or quite boiler pressure by the time the crank has advanced to the end of its stroke, or by the time the valve admits

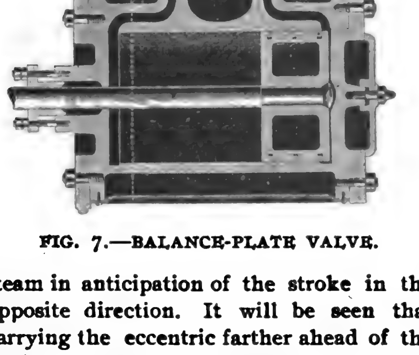
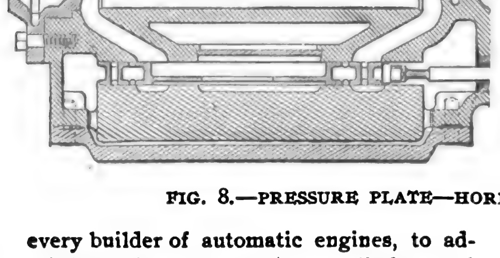


FIG. 7.—BALANCE-PLATE VALVE.

steam in anticipation of the stroke in the opposite direction. It will be seen that carrying the eccentric farther ahead of the crank, will make all these events commence and terminate earlier, and if more compression is wanted with an earlier cut-off, it is only necessary to advance the eccentric; but when a later admission is required with the later cut-off and more compression, the slide valve will not give it, except by putting another valve on top of the plain slide—the office of the new valve being merely to control the point of cut-off. By changing the lap of the valve, both steam and exhaust (if there is any of the latter) the points in the cycle of events can be changed, but once fixed by the builder, they cannot be changed. The change in travel and lead is the limit while the engine is running.

The relative travel of valve and piston can perhaps be shown in the most simple manner by Fig. 6. A study of this diagram will reveal its full meaning with little description. It is only necessary to state that the line *A*, represents the cylinder, and the graduations show the movement of a piston connected with a 16-in. connecting rod. The preceding diagrams have been borrowed from *Power*, issues of March, 1894, and January, 1896.

The great objection to a "riding cut-off valve," is the excessive pressure to which the valve is subjected. It is the desire of



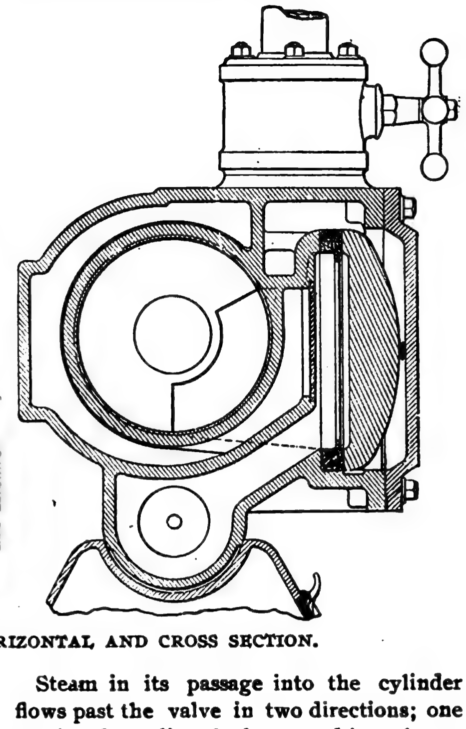


FIG. 8.—PRESSURE PLATE—HORIZONTAL AND CROSS SECTION.

every builder of automatic engines, to admit full boiler pressure to the cylinder, and

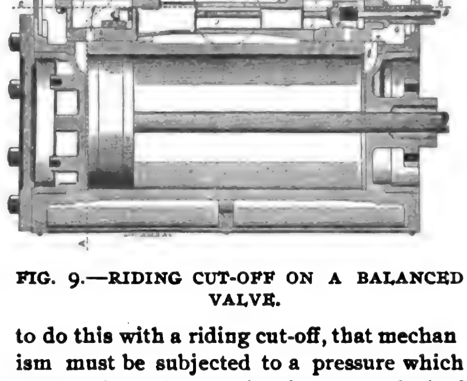


FIG. 9.—RIDING CUT-OFF ON A BALANCED VALVE.

to do this with a riding cut-off, that mechan ism must be subjected to a pressure which causes the valve to absorb a great deal of power in its operation. Throttling engines have their valves protected from excessive frictional pressure by the governor, but automatic engines do not have this safeguard, and it is customary to "balance" the valve by removing the whole or a large part of the pressure from the surface opposite the port openings.

In a number of engines, this is effected by the use of a "balance plate," as very clearly shown by Fig. 7. In this form of construction, the valve is nothing more than a square box without top or bottom—a mere rectan-

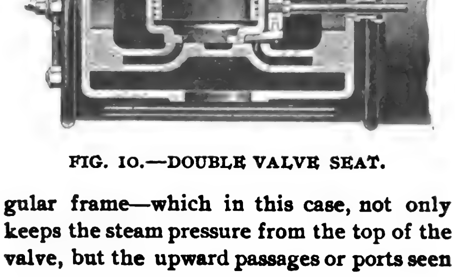


FIG. 10.—DOUBLE VALVE SEAT.

gular frame—which in this case, not only keeps the steam pressure from the top of the valve, but the upward passages or ports seen in the engraving, also lead direct to the cylinder, thus securing greater port opening for a given movement of valve.

Steam in its passage into the cylinder flows past the valve in two directions; one portion flows directly downward into the cylinder; the other portion flows upward into the balance plate and thence through ample passages into the cylinder. The effect of this is to produce an equal pressure in opposite directions over every portion of the valve. Without the port opening upward in the balance plate there would have been an area of the valve equal to that of the ports acted on by pressure on one side only and consequently unbalanced. The result of this construction is, at least, to give a slide valve which is, theoretically, perfectly balanced.

The balance plate is fitted with pins or dowels which prevent it from moving laterally, and it is held in position against its seat by springs on the back. This construction

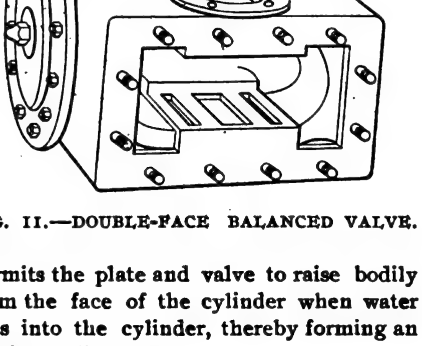


FIG. 11.—DOUBLE-FACE BALANCED VALVE.

permits the plate and valve to raise bodily from the face of the cylinder when water gets into the cylinder, thereby forming an efficient relief valve.

Another application of the balance, or pressure plate is shown by Fig. 8. This valve is a rectangular plate, quite thin, with five openings through it. It is made flat on the two sides, and of uniform thickness. The valve works in an opening formed by the valve seat, the pressure plate and two distance-pieces placed above and below the valve, which stands on edge. The pressure plate is made about $\frac{2}{1000}$ in. thinner than the distance-pieces, so that the pressure plate

relieves the valve of all pressure, and the slide valve becomes virtually a flat piston valve.

There are recesses in the pressure plate which, in connection with the small openings in the valve, form double ports, both for steam and for exhaust. Overpressure

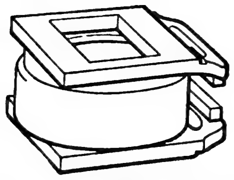


FIG. 12.—"CHEESE-BOX" VALVE.

and water in the cylinder are relieved by the valve and pressure plate lifting from their seats, the plate being held thereto by springs, as in the last example.

Fig. 9 shows the application of a riding cut-off to a balanced slide valve. The steam enters at *D*, and passes through the cavity, *a a*, to the balance pistons, *d*, through which it passes to the interior of the valve, *I*, *I*, as shown by the arrows in which chambers boiler pressure is maintained constantly when the engine is at work. The balance pistons are packed with steam, metal snap rings and followers, *F*, and are fitted to work steam-tight on the face of the cover-plate of the valve, forming a steam-tight communication between passages, *a*, *a*, and the moving valve.

The coiled springs, *E*, hold the valves to their seats when steam is shut off, and steam is admitted to the cylinder from the inside of the valve through ports in its face, which are closed by the cut-off valves, *c*, *c*, attached to the stem, *g*. These plates cover the valve ports according to their travel, which is determined by the governor. The valve is shown as just beginning to admit steam at the left hand, as shown by the arrows, while at the other the cylinder port is shown partly open for the exhaust, which passes into the chest, *G*, thence into the pipe, *K*, the course being indicated by arrows.

The area of the balance pistons is such as to hold the valve to its seat against the pressure in the valve and cylinder ports, which tends to throw the valve off. This pressure is always variable, being greatest when the cylinder is taking steam, and less after cut-off. To counteract this excess of pressure, the channels, *e*, *e*, are cut in the valve faces and connected with steam from the inside of the valve through the passage,

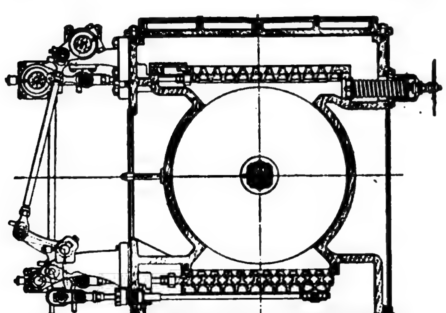


FIG. 13.—"GRIDIRON" VALVE.

f, only that end of the valve which is exhausting being thus connected.

This valve has a positive travel of uniform extent; that is, the bearing surfaces always sweep over their whole extent so that the wearing of a ridge or a "cradle hole" as with the common slide valve, is impossible. The cut-off valve gives a very sharp closure at all loads, for it is so arranged that it cuts off about in the middle of the stroke, no matter whether closing late or early. In either extreme, there is a travel of one-third the whole distance after closure. Reduced clearance is a feature of this valve, owing to its being placed so close to the bore of the cylinder. As the steam chest never contains anything but exhaust steam, the cover may be removed and the engine operated in that condition, which will at once reveal any leakage of the valves. Another peculiarity is that if any steam leaks past the cut-off valve, the waste is stopped by the main valve. As this valve is connected direct to the eccentric without passing through the governor mechanism, there is little to be feared from accidental derangement of the

FIG. 14.—STEAM VALVE—GRIDIRON.

governor. A failure of that appliance could only affect the riding cut-off, not the main valve.

A form of double, opposite-ported valve, is shown by Fig. 10, which dispenses with the pressure plate noted in Figs. 7 and 8. In this type, it will be noted that the valve stands with its edge toward the cylinder, and that steam passes from the interior of the valve to the cylinder in two equal directions, and that the exhaust passes around the cylinder in the form of a steam jacket, to the escape pipe. The benefit to be derived from a steam jacket of 212 degs. temperature, is, to say the least, doubtful, though it

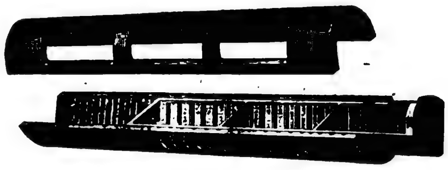


FIG. 15.—EXHAUST VALVE—GRIDIRON.

may be contended that the exhaust steam is many degrees hotter than atmospheric temperatures which usually surround the cylinder.

A peculiarity of this valve is the method in which it is made steam-tight at all times when steam is on. Plainly speaking, the valve resembles a pair of "cheese boxes" slipped one within the other, and a square board on either end, cut to form the valve faces. The manner of making the telescopic sleeves steam-tight by three snap rings, is clearly shown; also the manner of attaching the valve to the stem, allowing the valve to be removed for examination at any time without disturbing any of the adjustments. The direction and action of steam is also clearly shown, both during admission and exhaust movements.

Fig. 11 shows that the valve seats are like those of the ordinary slide-valve type, cast in one piece with the cylinder, and depending neither upon pins nor bolts to always remain in alignment with the cylinder. There is no pressure plate to deal with, but water

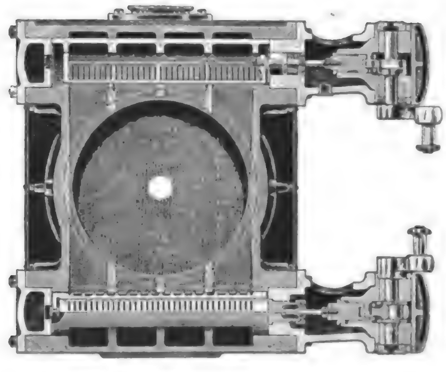


FIG. 16.—CAM AND CRANK MOVEMENT.

in the cylinder finds a ready escape by forcing the "cheese boxes" a little closer together, and escaping directly into the exhaust cavity. Fig. 12 is a cut of the valve as removed from the cavity in Fig. 11. This valve belongs to the straight-slide type, partially balanced, with enough lack of perfect balancing to keep it tight on its seats. Regulation is performed by changes in travel and lead.

A peculiar but old adaptation of the slide valve is illustrated by Fig. 13. This is known as the "gridiron" type, owing to there being a number (eleven in this valve) of spaces for the passage of steam through the valve, making it look like a gridiron or a grate bar. It is placed, like a Corliss valve, crosswise of the cylinder, and is moved endwise over a valve seat patterned with holes exactly like the valve. A riding cut-off of similar pattern is placed on top of each steam valve, there being one of these for each end of the cylinder. The exhaust valves are of similar pattern with the cut-off omitted.

The four main valves are actuated by a single rock-shaft which is very strongly driven, and has a positive movement. The cut-off is driven by another rock-shaft, the time and travel of which are directed by the governor, while the motion remains positive after its extent has been fixed as above. While considerable power is required to drive these valves, a good deal of steam is saved by the exceedingly small clearance space made necessary by their use. The peculiarity of the gridiron valve is great port opening with small movement of the valve, and great tightness.

Another type of "gridiron" valve is shown by Fig. 14; being made in the form of a trough, it is very strong, and not apt to get

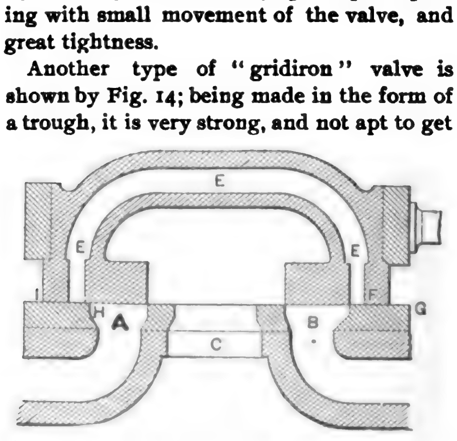


FIG. 17.—DOUBLE-PORTED SLIDE VALVE.

out of shape. This is for a four-valve engine, and the exhaust valve (Fig. 15) is inverted. The position of these valves so close to the bore of the cylinder, as seen in

Fig. 16, ensures a small clearance. The exhaust valve is moved by a shaft having end-motion, and connected with the valves by cranks. The steam valves are moved in a similar manner by means of an end-motion shaft, but the degree and durance of the motion is controlled by the governor, thus opening the valves at different lengths of time, as the load demands.

Instead of a crank to operate the steam valves, there is a cam which pushes the valve open, and then retires very quickly. The valve is forced by unbalanced end pressure back to its closed position, thus following back the cam quick enough to give a sharp closure of the valves. This valve and motion is designed particularly for large, heavy-duty engines, and is said to give a Corliss distribution without the load of cams, springs and dash-pots usually carried.

Another form of slide valve partaking of the double-ported type, is shown in Fig. 17. Twice the port opening is secured by a given movement of this valve. When the valve moves to the right, the point, *F*, of the valve passes over the edge, *G*, steam passes under the right-hand of the valve through the passage, *E*, to the steam port, *A*; while at the same time the edge, *I*, of the valve moves past the edge, *H*, of the port, *A*, allowing steam to enter as in an ordinary valve. This valve is often used on locomotives to shorten the travel, and thereby reduce the power necessary to handle the valve.

FIG. 1.—WALKER 200 HP MOTOR.

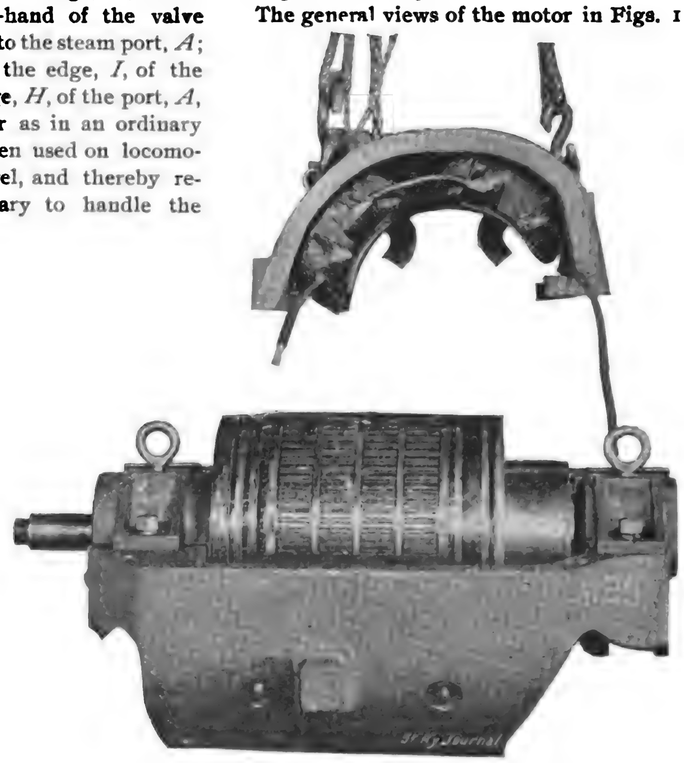


FIG. 2.—WALKER 200-HP MOTOR.

REPAIR OF ELECTRIC RAILWAY APPARATUS.

THE WALKER NO. 25 MOTOR.

This motor, rated at 200 HP and perhaps the most powerful motor built as a standard product, is the latest design of Prof. S. H. Short. It has not been on the market long enough to have a break-down or burn-out, and therefore its repair is not widely known. To that subject this article is devoted, sufficient descriptive matter being incorporated to render the comprehension of the details of repair more easy.

The general views of the motor in Figs. 1 and 2, give a sufficient idea of how to remove it from its suspension on the truck. It should be run under a crane, and tackling should be made fast to the staples cast in the top of the casing, and the four cap-bolts securing this to the lower part of the casing should be removed. The field connections should then be broken, when the top may be lifted off, exposing the armature to view. If it is then necessary to remove the motor altogether from the suspension, the tackling should be made fast to the eye-bolts in the tops of the bearings, and the eight nuts

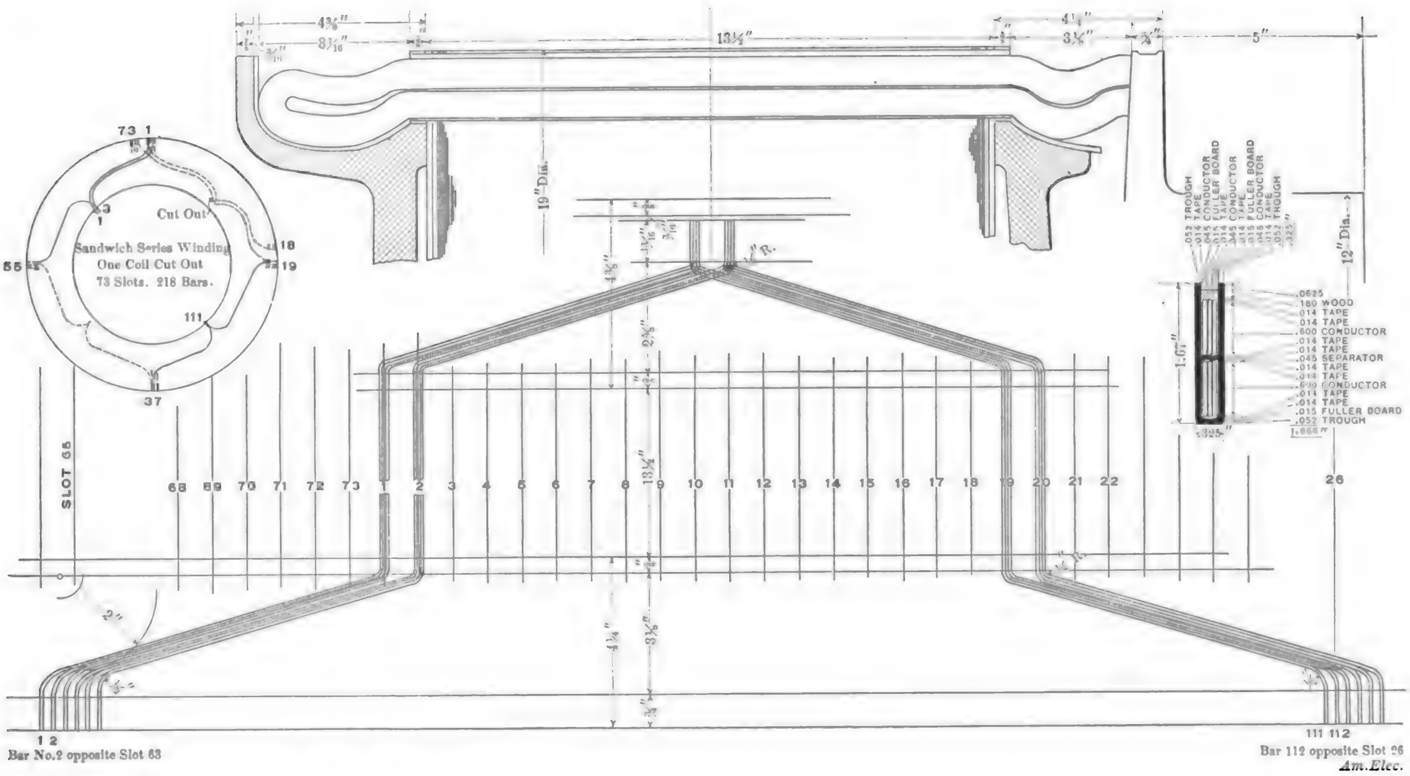


FIG. 3.—DIAGRAM OF WINDING.

which secure the caps over the bearings surrounding the car axle should be taken off, care being taken not to lose the spring washers which prevent them from jarring loose. The motor may then be lowered slightly and disengaged from its suspension and then completely lowered into the pit underneath the car.

The armature may be lifted from the lower field casing by removing the cap-nuts and hoisting on the tackle secured to the eye-bolts in the t›p of the bearings. The armature may then be conveniently let down on the floor. The bearings may be slipped off and a fresh grip of the tackle taken around the ends of the shaft for the purpose of swinging the armature on to the rack prepared for the winder. The bearing shells are doweled top and bottom and can be easily removed after the shaft is slipped out.

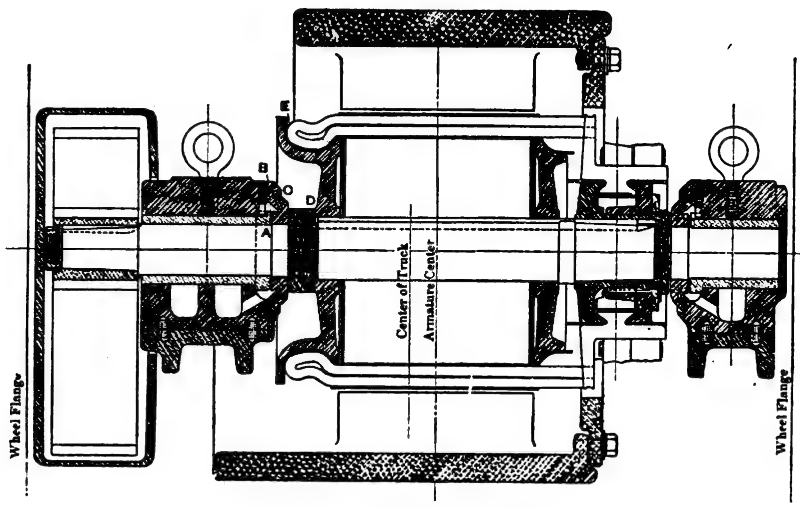


FIG. 4.—SECTION OF MOTOR.

The field coils require to be wound on a special form built to fit them. The wire used is No. 0000, and there are 35½ turns to a coil. The wire being so heavy, it is more or less difficult to wind, but will not give much trouble from subsequent displacement when once wound. The adjacent coils are taped together by winding in strong strips of tape as the work proceeds. Careful examination of the old coil as it is unwound will materially assist the winder in preparing a new one.

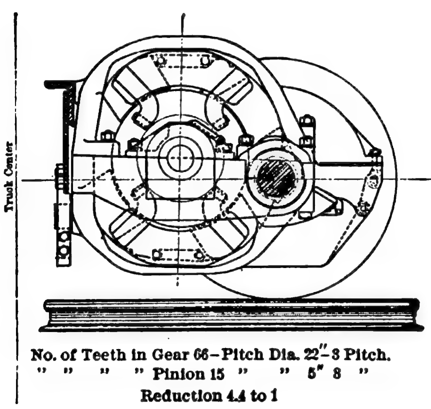
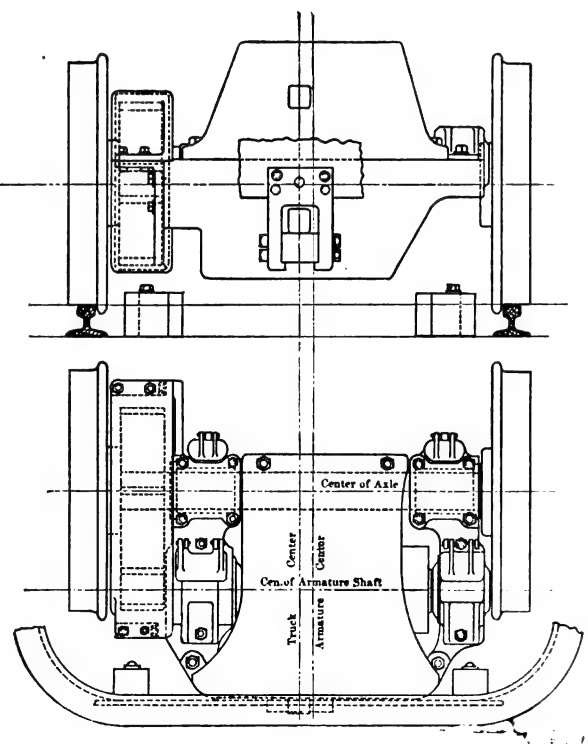


FIG. 5.—SUSPENSION OF MOTOR.

The repair of the armature is, of course, not so easy to understand, but the labor involved is very small. The first thing to do is to remove the band wires, and having ascertained which coils are burned out, it will be necessary to unsolder one-half of the commutator bars from their connections before the coil can be freed. Referring to the diagram of the winding (Fig. 3), in order to release coil No. 1, it will be necessary to unsolder from bar No. 1 to bar No. 113, and the coils from slot No. 1 to slot No. 19 must be lifted. The coils are assembled in bunches of three by strong tape which is sticky on the inside only. The flat ribbon which forms the conductor is .045 in. thick and .6 in. wide.

A section of the slot is shown in Fig. 3, from which the various thicknesses of insulation employed can be determined. A sectional drawing of the motor (Fig. 4) and the winding diagram (Fig. 3), show the end connectors as curved; this, however, is not the case. The curved line simply shows the section of the assembled head and not the shape of the individual coils, which are all in straight lines. The fact that they are diagonally placed with regard to the armature shaft causes the ends of the connectors to be further from the center of the shaft than the middle, thus producing the curved section shown. This is not an easy matter to understand, but it is not necessary that the winder should understand it, for if he makes the coils of the proper shape and fits them into the armature according to the diagram, the curved surface of the armature head will develop of itself.



The dimensions of the coil are given in Fig. 3, but the diagram is not to scale. There are seventy-three slots in all and three times as many commutator bars less one, for it is necessary to cut out one of the coils in order to make the wave winding employed close in on itself; this coil is simply left on open circuit in the armature, and is not soldered into the commutator in any way. Each commutator bar carries two connections, with an upper conductor and with a lower one of the next coil, in the ordinary manner.

After the coils are in place, band wires are wound into the depressions at either end of the winding. These bands are depended on to hold the coils in place. A piece of canvas duck is then wrapped about the lugs on the commutator end and secured in place by winding in a band in the groove provided for that purpose. It is then turned over on to the armature, drawn tightly up and marked, turned back and sewed together, and then turned on to the armature again and bound in place by an appropriate band. In a similar way the other end of the armature is headed. The outer bands are more for the purpose of securing the wooden fillers in the top of the slots in place than for confining the coils.

Consulting the sketch in the top of the winding diagram, there will be found dimensions and locations which will greatly assist in insulating and dressing the armature.

It is not best to attempt to refill the commutator unless special apparatus is provided, for the result will be inferior to the original commutator, which is set up in a powerful clamp and subjected to a pressure of many tons to the square inch at a high temperature.

The commutator is fastened to the shaft by means of a nut and taper-sleeve and key, as shown in the sectional drawing, which also gives details of the commutator sleeve and the insulation thereof.

The motor is provided with four studs, and the brush holders can be adjusted either above or below, as is most convenient. If in the upper position the positive brush is on the right side, that brush will be on the left side if they are transferred to the lower position.

This motor was designed for elevated railway work and situations where a reasonable amount of cleanliness in the roadbed is assured, and therefore, is left open at the ends for better ventilation and can carry enormous overloads. The pole-pieces are not an integral part of the field casting, but are secured thereto by bolts. The dia-

grams of the suspension of the motor are shown in Fig. 5. The Walker suspension is not used with these large motors as they ride more like a locomotive and thus do not require it.

INDUCTANCE AND CAPACITY.

Owing to the very little treatment that the subjects of inductance and capacity have received except in a mathematical way, and also to their very great interest as alternating-current phenomena, at the risk of some repetition we shall, in this article give a résumé of the principles established in previous articles, with some additions.

While it is possible to explain the phenomena of both inductance and capacity by reference to lines of force, it is very much simpler to confine this method to inductance and to treat a condenser as an apparatus having a capacity for electricity, into or from which electricity flows when the potential

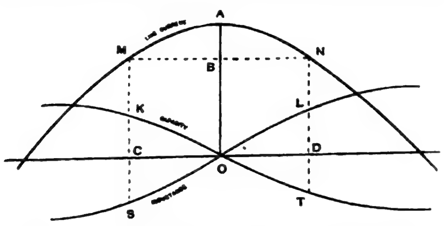


FIG. 1.—CURVES OF ALTERNATING CURRENT, AND INDUCTANCE AND CAPACITY E. M. F.

of the two sides of the condenser is unbalanced, which unbalancing may be considered to occur continuously in a circuit carrying an alternating current.

Referring to Fig. 1, suppose that the sine curve, *M A N*, represents the variation of current or E. M. F. in an alternating-current line during one alternation, the value of the current or E. M. F. increasing from zero to maximum in one quarter of a period, then falling again to zero in the second quarter; in the second half of the alternation, which is not represented, the values decrease to a negative maximum and finally at the end of the period rise again to zero, thus completing a cycle.

Time is measured along the line, *C O D*, and *C O*, for example, represents the time required for the current to pass from the value, *C M*, to the value, *O A*. In passing from the value, *C M* to *O A*, the current has increased in strength by an amount *A B*, and since each value of current carries with it a certain definite number of lines of force, the number of lines which will have been added to a coil, we will say, in the circuit, will also be represented by *A B*. While being added to the coil these movable lines may be considered to cut the stationary conductors in the same manner that in a dynamo moveable wires cut stationary lines of force, and consequently the coil will act precisely as a dynamo with respect to generating E. M. F.

While the current is increasing, as from *M* to *A*, these lines will cut the coil in such a way as to set up an E. M. F. opposing the E. M. F. of the line, which E. M. F. will tend to set up a current in the opposite direction to the current of the line. That is to say, referring to Fig. 1, if *S O L* is the curve showing the variation of the inductive E. M. F. thus set up, at the point *M* the value of this will be *C S*, and as this is negative in direction while that of the line is positive, the resultant current flowing in the line will be less than *M C* by the amount, *C S*.

At the point, *N*, the lines of force are cutting out of the coil and will therefore tend to set up a current in the same direction as that flowing in the line; consequently, the line current, *N*, will be increased by the amount of the inductive current, *D L*.

That is to say, when an alternating current is increasing in value, it tends to generate a current opposite in direction to that of the line current; and when an alternating current falls in value, it tends to set up a current in the same direction as the line current. In other words, an inductance when an alternating current is increasing in value acts as a dynamo generating current opposite in direction to that of the line, and when the current in the circuit is decreasing in value, it acts as a dynamo generating current in the same direction as the current flowing in the line.

Another way of looking at the subject is to consider that with an increasing current an inductance acts as a motor in a circuit, generating a counter E. M. F. opposed to the impressed E. M. F. of the circuit; and with a decreasing current it acts as a generator or booster, and adds its E. M. F. to that of a circuit.

Referring again to Fig. 1, suppose that *K O T* represents the variation of current due to the introduction of a capacity into circuit. When the E. M. F. of the line increases in value, with each increase a condenser in the circuit will be unbalanced or have its capacity for current increased by the amount corresponding to the increase of E. M. F. Consequently at a point, say *M*, of an increasing current, the amount of current which the unbalancing referred to causes to flow in the condenser will be represented by *K C*, and as this is in the same direction as the current flowing in the line, the total amount of current in the line will be the sum of *M C*, the line current, and *K C*, the condenser current. When a current is decreasing in value—at the point, *N*, for example—the condenser will give forth current opposite in direction to the line current, of the value, *D T*, thus decreasing the line current from the value at *N D*, which it otherwise would have, to a value corresponding to the difference of *M D* and *D T*.

It will thus be seen that an inductance and a capacity have diametrically opposite effects, an inductance generating E. M. F., in the same direction as the line E. M. F. when the capacity is throwing into circuit an E. M. F. due to a current opposite in direction to that of the line. It is, therefore, readily seen that if an inductance and capacity in circuit have such relative values that the amount at any given instant of these E. M. Fs. is equal, the action of each will be nullified and the circuit will act toward alternating currents in precisely the same manner as toward continuous currents, there being, while it is increasing in value, no choking due to inductance nor additional current due to capacity; and with a decreasing current no choking due to capacity and no increase of current due to inductance.

This is further represented in Fig. 2, where *B* is a curve of the impressed E. M. F. in an alternating circuit and *A* the current flowing in that circuit due to this E. M. F., *D* and *C* being the E. M. Fs. due respectively to inductance and capacity. It will be seen that at every instant the positive value of one of these is balanced by the negative value of the other; their E. M. F. being thus balanced against each other, they are consequently nullified so far as the E. M. F. of the circuit is concerned, and consequently the current in the circuit will rise and fall in phase with the impressed E. M. F. That is, the current and E. M. F. will have their zero and maximum values at the same instant of time.

Although the case of an inductance alone in the circuit has been considered in a previous article, we will take it up again in order to contrast it with the case of a capacity alone in circuit. Referring to Fig. 3, *A* is the current in an alternating circuit as measured by an ammeter. The E. M. F. which sets up this current is represented by the curve, *B*, which must be in phase with the current, and which we will call the free E. M. F. *D* represents the inductive E. M. F. set up by the current, *A*, flowing through a coil in circuit. Combining *D* and *B* by adding their E. M. Fs. when in the same direction, or subtracting them when in opposite directions, we get the curve, *F*, which represents the E. M. F. that would actually be measured between the extremities of the coil in question.

That is to say, as in the case of a continuous-current motor, the impressed E. M. F. is the resultant of the free E. M. F. and the E. M. F. set up in the inductance coil, which corresponds to the counter E. M. F. of the motor. The free E. M. F. of a motor, which is the difference between the E. M. F. at the binding posts and the counter E. M. F., cannot be measured at the binding post of the motor any more than at the extremities of an inductance. It should be remembered that current is the effect of E. M. F., and therefore must always be proportional to the free E. M. F. and always in phase with it. In other words, when the free E. M. F. is at zero value there is no current and when the free E. M. F. is maximum in value the current is also highest. What is measured at the binding posts of an

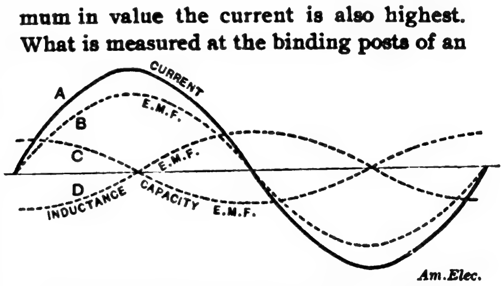


FIG. 2.—CURVES OF INDUCTANCE AND CAPACITY.

alternating-current apparatus having inductance is the E. M. F. which is necessary to supply the free E. M. F. causing current to flow and also E. M. F. to balance the E. M. F. generated in the coil itself. In the case of five primary cells, for example, if two of these were balanced against two others, the E. M. F. causing current to flow will merely be that of the one unbalanced cell, or the free E. M. F. of the circuit will be that of this one cell, notwithstanding that there are in circuit five cells.

Referring to the left of Fig. 3, if the circle represents the armature of a bipolar dynamo, a pole-gap being at *T'*, then the free E. M. F. would be as if it were generated by a conductor at *B*, the impressed E. M. F. as if generated by a conductor at *F*, and the inductive E. M. F. as if generated by a conductor at *D'*. Suppose that *B O*, represents the value of the free E. M. F., and *O D* the value of the inductive E. M. F.; then the resultant of these two will, by the parallelogram of force, be *O F*.

It will thus be seen that there is an angle between lines drawn to the conductors representing respectively the free and impressed E. M. F.; and assuming clockwise motion, it is said that the free E. M. F. is behind the impressed E. M. F., though, as here drawn, this is only true when the period is supposed to begin in the middle of the cycle shown. As, however, the current and free E. M. F. are in phase, it may be said that, as represented in a clock diagram, the current lags behind the impressed E. M. F.

Now, taking up the case of capacity, we have again the line current, *A*, the free E. M. F., *B*, and the capacity E. M. F., *C*, and *F* the resultant of the free and capacity E. M. Fs., which is the impressed E. M. F. or the E. M. F. that would be measured at the binding post of a condenser. In a similar manner we can consider the several E. M. Fs. with relation to a bipolar dynamo. In this case the free E. M. F. would be generated by a conductor at *B*, and capacity E. M. F. by a conductor at *T'*, and the impressed E. M. F., which is the resultant of the two first mentioned, by a conductor at *F*. It will here be seen, however, that the free E. M. F. (referring to the middle of the cycle drawn) is ahead of the impressed E. M. F., so that in the case of a circuit containing capacity the E. M. F. lags behind the current, which is opposite to what occurs in a circuit containing inductance alone.

In the figures the zero of capacity and inductance E. M. F. should coincide with the maximum value of current, for at that point the rate of change of current and lines of force is zero.

As has just been shown, the variation of E. M. F. in a circuit may be represented by what is called a clock diagram, or which should rather be considered as a representation of a bipolar dynamo. One should not, however, lay too much stress upon this analogy, however valuable it may be in the mathematical treatment of alternating currents. What seems to be the most instructive way of viewing the subject is to consider that the impressed E. M. F. in a circuit containing inductance and capacity has three components; first, free E. M. F. to which the actual current flowing is due; second, two components, relating to the inductance and capacity of the line, respectively.

As stated before, in the case of a motor, the impressed or binding post E. M. F. has two components, one of which is balanced by the counter E. M. F. generated, the motor armature acting as a dynamo in cutting the lines of force of its field; the second is the *C R* E. M. F. in virtue of which current flows through the motor. In this case, if we have the two latter, we obtain the resultant or impressed E. M. F. by simple arithmetical addition.

Now referring to Fig. 4, we see that on account of the variation of the E. M. Fs. in an alternating circuit, ordinary addition does not apply. Nevertheless, the same principles apply as in continuous currents, and by compounding the curve, *D*, with the curve, *B*, we get a resultant, *F*, which corresponds to the arithmetical sum mentioned above. By laying down the E. M. Fs. as shown above, we get a physical view of difference of phase and of lag entirely independent of the clock diagram, and not obscured by consideration of angles and other things so foreign to one's conception of electrical current and E. M. F. When it comes to alternating-current calculations, however, the clock or bipolar dynamo diagram is valuable, since it very clearly shows the reasons for the use of the parallelogram of forces in the calculation of alternating-current phenomena.

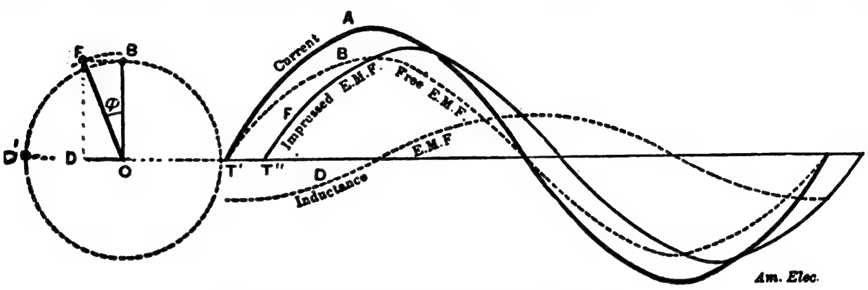


FIG. 3.—INDUCTANCE ALONE IN CIRCUIT.

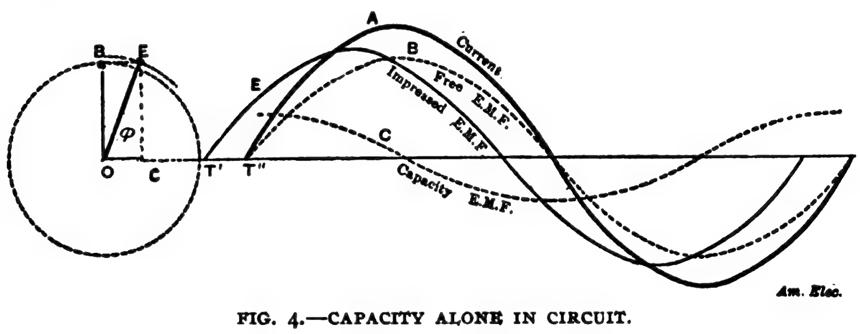


FIG. 4.—CAPACITY ALONE IN CIRCUIT.

SOME ELECTRICAL SPORT—II.

BY JAMES F. HOBART, M. E.

Under supervision of the writer, who used to be greatly troubled by street gamins, who persisted in passing their time in looking through the windows of the station at hours both inconsistent and unreasonable, some wire netting was applied to the outside of the windows to keep the boys out; but it failed to prevent their looking in. They would stand, dozens in number, with fingers clinched into the netting, and stare with open mouth into the station.

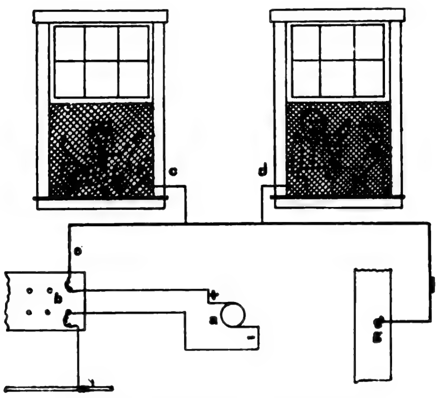
It was fully determined to give the little rascals a dose of electricity. To do this, a scheme was rigged up as shown in Fig. 2. *A*, represents the dynamo, *b* the switchboard, *c* and *d* a pair of windows covered with poultry netting, and *e* is a very fine wire that was connected to the netting on the windows, and also connected to the positive lead of the dynamo. *B*, is the board, and when using a spare dynamo, for the purpose here explained, great care should be taken that no connection exists beyond the switch-board, except to connect the negative lead of the dynamo with a good ground formed by connecting wire, *f*, with a steam pipe. A special connection for this purpose was rigged on the switch-board, and it was only necessary to put in a plug when such connection was desired. There was always one or two spare dynamos in the station. Whenever a good group of boys appeared at the window, a 25-light arc machine (Thomson-Houston) would be started up ready for business. When the engine was running, and the boys had their fingers in the netting, a plug at switch-board would be put in place, and the boys were hung up for repairs in the most effective manner. Only in very dry weather was it necessary to ground the dynamo in order to shock the boys. There seemed to be a certain amount of static electricity that was always free to run away from the circuit, and this static electricity would generally give the boys all they wanted.

In using a dynamo for this purpose, capable of generating 1000 volts, some precaution should be taken to prevent giving the victims too much of the "juice" or they might be "electrocuted" in earnest. This precaution consists of making wire *e* very small. No. 36 magnet wire was used for this purpose, and a piece 15 ft. long connected the window netting with the negative lead of dynamo. Before enough current to do any harm to the boys could be forced through this fine wire, it would be melted and connection with the dynamo broken.

Several times the experiment was tried by using an ordinary circuit with two dynamos connected in series. The static electricity from this current was very good and would hang a pair of urchins so thoroughly that they could not possibly let go until the current was broken. The danger of using a current that was feeding lights was much greater than for using a single dynamo running light. This excess of danger is due to the "electrical kick," which would take place at the instant the current might be broken. The tension of such a "kick"

might mean 40,000 or 50,000 volts, and would in all probability kill the children before the wire would burn off.

To make sure of safety, the idle dynamo was used, as shown in Fig. 2. This device was used for several "shocking" things. For instance, the wire was taken off the opposite side of the dynamo, and carried many feet distant to the engine room, where it was connected with a spike driven into a post. On the spike was hung a tin dipper, used for drinking purposes. Everybody used to use this dipper, and many times they would forget to hang it up when done with it. After the above connection was made, nobody troubled the dipper more than once



SOME ELECTRICAL SPORT.

(even then they did not remove it from the nail) and the first time they tried it, they seemed to lose all desire to try it the second time.

A piece of board was laid conveniently on the ground (the floor of the boiler room was moist earth) and when the engineer or fireman wanted a drink of water, he would step carelessly to the dipper, and somehow or other managed to stand on this board when taking the dipper from the nail. The board formed an insulation between foot and ground, and no shock was felt when removing the dipper, *g*, when standing as above.

Letters on Practical Subjects

Compounding Characteristics.

To the Editor of American Electrician:

Will some of the correspondents who are so situated, determine and submit for publication the compounding curve of voltage on direct-connected, continuous-current dynamos of any capacity from 200 KW down and for speeds not exceeding 300 r. p. m.

Springfield, O. S. R. THOMAS.

Horse-Power and Kilowatts.

To the Editor of American Electrician:

The following simple rule may be of interest to such of your readers as are not already acquainted with it: For the rapid calculation of the HP of a dynamo, divide the KW-capacity by 3, and add the quotient to the KW capacity, and the answer is the electrical HP. Example: 90-KW machine; $\frac{90}{3} = 30$; $90 + 30 = 120$. Proof: 90 KW = 90,000 watts; $\frac{90,000}{746} = 120.8$ HP. Similarly, to find the KW corresponding to a given HP, reduce the HP by one-fourth—that is, take three-fourths of the HP. For instance, 100 HP is almost exactly equivalent to 75 KW.

Mobile, Ala. JOHN R. JENNINGS.

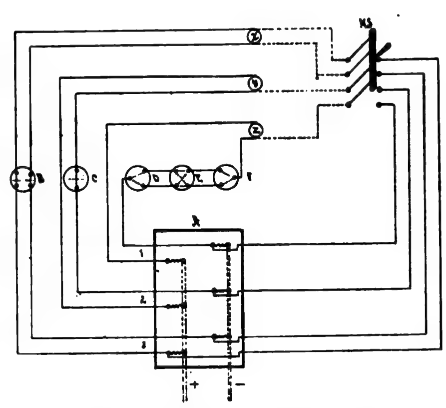
Switch Combination.

To the Editor of American Electrician:

The accompanying sketch represents a combination of switches which is sometimes used in residence wiring. The "night switch" is frequently called a "burglar alarm switch" and made to close automatically in connection with the regular burglar alarm system.

A is a fuse tablet in which the short crooked lines are the fuse links, the black spots the binding screws, and the dotted lines the bus-bars or mains. 1 is a circuit supplying a current of 6 amperes to outlet *Z*. *D*, *E* and *F*, are 3-way, 4-way, and 3-way switches, respectively.

Outlet *Z* may be turned on or off from either one of the three switches, *D*, *E*, *F*. 2 is a circuit supplying a current of 6 amperes to outlet *Y*. *C* is a single-pole switch. Outlet *Y* may be turned on or off



COMBINATION OF SWITCHES.

from switch *C*. 3 is a circuit supplying a current of 6 amperes to outlet *X*. *B* is a double-pole switch. Outlet *X* may be turned on or off from switch *B*. *NS* is a "night switch" (4-blade knife switch) which when closed, lights the outlets *X*, *Y*, *Z*, and prevents their being turned off by any of the switches, *B*, *C*, *D*, *E*, *F*.

St. Louis, Mo. P. C. FISH.

Three-Wire Secondary Wiring.

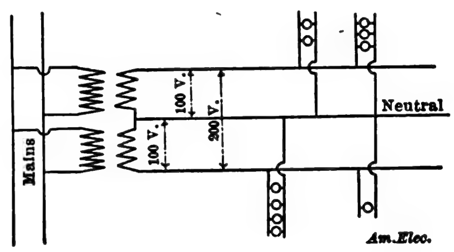
To the Editor of American Electrician:

There is one system of wiring that to the mind of the writer has not been given the study its importance demands, and that is the three-wire 200-volt system for alternating currents.

Among the several advantages is the large saving in copper, particularly where it is some distance from the transformers to the distributing points.

Take, for instance, a distance of 250 ft. from the transformer to the distributing point of 100 16-CP lights; assuming a loss of 2 per cent., if the two-wire- 100-volt system is used the wiring tables would call for a No. 00 B. & S. wire. Now take the three-wire plan with the same per cent. loss, the size wire required would be No. 2 B. & S. with one length of No. 10 B. & S. for the neutral or third wire, or a saving of over 100 per cent. in favor of the three-wire plan. Again, increasing the voltage decreases the amperes, and as the inductive drop is in proportion to the current, reducing the current reduces the inductive drop, thereby permitting a greater per cent. of ohmic drop, which will allow of still smaller wire. Another point is that it is easier to install two lengths of No. 2 and one of No. 10 than two of No. 00.

The only thing for the wireman or engineer to be careful of is to keep both legs balanced, and by using good judgment it will be an easy matter, as it can generally



THREE-WIRE SECONDARY CIRCTIT.

be told from the character of the buildings to be wired, which rooms therein will use the lights the most. For instance, suppose rooms 1 and 2 use lights twice as much as rooms 3 and 4, then it would be advisable to put rooms 1 and 2 on one leg, with 2 and 4 on the other, so that at no time should the neutral or middle wire have to carry more than one-quarter of the total load, on which basis it would be safe to calculate the wire for the third or middle wire.

Though the writer knows of at least one manufacturing concern that makes a transformer for such wiring, any central station has always some transformers with the secondaries connected for 100 volts, by connecting them, as shown in the diagram, with the primaries in multiple on the mains, then all that is necessary is to connect the secondaries of the two transformers in series, with the third wire connected on where the two secondary wires are joined together.

Bay City, Mich. JOHN I. THORNE.

Dynamo Reversals of Polarity.

To the Editor of American Electrician:

The letter of Mr. S. T. Comstock in your September number is interesting, though somewhat surprising to the writer, in view of the facility with which shunt machines reverse their polarity, according to Mr. Comstock's experience. Series ma-

chines reverse, as is well known, on the slightest provocation. Anything that will send a momentary current back through the machine will reverse it.

For instance, an arc machine under normal conditions, furnishes an E. M. F. that is used up in two ways—partly in the drop due to the ohmic resistance of the line, including carbons and arcs, and partly in overcoming the counter E. M. F. of the arcs. Moreover, an arc does not usually go out instantaneously, but requires an appreciable time.

If, therefore, the E. M. F. of the dynamo be very suddenly reduced below the counter E. M. F. of the arcs, a current will go back through the dynamo sufficient to reverse it, if it be a series machine, although the duration of this current may be only a small fraction of a second.

When the belt breaks, or suddenly flies off the driving pulley of the dynamo, the conditions are good for reversal ot polarity, and it is very apt to take place. The writer once knew of a case of reversal of an arc machine, caused by the sudden stoppage of a main-line shaft in a machine shop, to which shaft the dynamo was belted. When the machinery started again, the workmen discovered that the ceiling was beautifully illuminated, but the work-benches were in comparative darkness. This happened in the year 1884 when this action was not so well known as now.

As to the reversal of shunt machines, whatever may be the true cause, the explanation given by Mr. Comstock appears to the writer entirely inadequate. Molecular friction is the cause of hysteresis. Hysteresis is merely the *lag in phase* of the magnetism of the iron behind that of the magnetizing force. In other words, the magnetism of the iron is always greater for a given magnetizing force when the magnetizing force is coming down, than when it is going up. This is true whether the magnetizing force be reduced slowly, as in some experiments, or very quickly, as in practice with alternating currents.

The idea that you can come down with a rush, so to speak, and let the momentum of the magnetism carry it past zero over to the negative side, is equivalent to assuming a negative hysteresis. In all the experiments on magnetism by Ewing, Steinmetz and others, there is not, so far as I am aware, a single case of this kind on record, except where there is a violent mechanical agitation of the iron purposely maintained during the experiment.

It seems highly improbable that the vibration of a dynamo under ordinary conditions of running could produce this result.

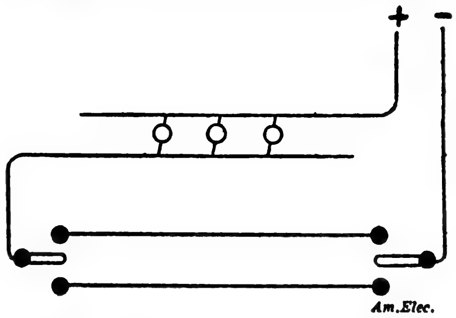
New York. TOWNSEND WOLCOTT.

Switch and Bell Circuits.

To the Editor of American Electrician:

There was evidently some mistake in the diagram furnished by Mr. J. E. Putnam, for "three-way" switches, on page 368 of the September issue, as by it only one side of the circuit is connected to the lamps.*

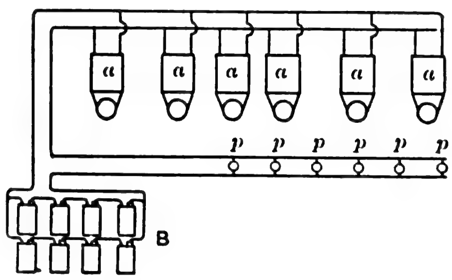
I think that the accompanying diagram meets the wants of electricians desirous of lighting one or more lamps from two different places much better than any other with which I am acquainted.



If it is desired to light from more than two places, any number of "four-way" or commutation switches may be cut in on the line with the switch station, this being impossible with other styles of wiring "three-way" switches.

I am also of the opinion that the diagram given herewith for ringing several bells at the same time from one or more places will work much better than the one given on page 369 of the September issue of the ELECTRICIAN.

In the diagram given herewith, *a*, *a*, are the bells connected in multiple, *p*, *p*, the



pushes, also in multiple, and *B*, the battery.

By this way of connecting much less battery power is required than when the bells are connected in series, and the results obtained are much better.

I know of one instance where twenty-two bells and two 8-in., two 10-in. and two 12-in. gongs are wired on this principle to ring simultaneously. Fourteen cells of carbon battery are used connected seven in series and two in multiple. The bells and gongs are run from two program clocks operated from an electric regulator, which also runs twenty-two other secondary clocks in the same building. The ringing is thus automatically done and the bells are rung about thirty times a day and give the best of satisfaction.

Some time since, I had occasion to install ten common 3-in. bells in connection with an interior telephone system, and to save wire ran the bells on the series principle and was unable to ring them all at once from twelve cells of battery, also connected in series. I afterwards connected the bells in multiple and the battery in series of three and multiple of three, thus using but nine cells of battery and obtained good results.

Manchester, N. H. S. E. SANBORN.

A Peculiar Phenomenon.

To the Editor of American Electrician:

The phenomenon mentioned in the letter of Mr. A. L. Torrance in your September issue is worthy of remark, but is not at all improbable, since the records of lightning show that there is practically no limit to the variety of its vagaries.

The difficulty, however, of forming a rational and perfectly satisfactory conclusion in any such case is very much enhanced by the considerations, that we can never be sure that all of the circumstances are reported, and that we can never be sure that some of the reported circumstances are not irrelevant and really "have nothing to do with the case."

The tendency of the average observer is to assume that all of the phenomena he observes are correlated, when the fact is that some of them are not; and, generalizing, he is likely to reach a wrong result; just as when, after a blasting explosion, somebody notices a well-fed toad hopping about the scene, having, not without reason, been disturbed in his noon-day retreat by the noise and the shock, and jumps to the conclusion that the batrachian has for thousands of years been enclosed within the now riven rock, and we are indulged with a multitude of newspaper accounts of the marvelous longevity of toads under trying environments.

In the present instance we have a telephone in use, a lightning discharge, a startled and damaged man, and a subsequently discovered, but extremely slight injury to the telephone. There is no positive evidence that the man was severely shocked by the lightning, or if he was, that the lightning shocking him came over the telephone wire; and the narrative contains no evidence whatsoever, direct or inferential, to the effect that the damage to the telephone diaphragm was done by the lightning.

Let us first examine the man. If he was grasping the hard-rubber telephone case alone, we may at once conclude that his shock did not come over the wire; for it is inconceivable that a discharge strong enough to disable a man for several days, and to act upon him through the rubber casing, would not also be strong enough to smash the telephone case, and burn out its coil. The man was probably touching some metal work also, received a slight shock, and coupling it with a flash and report, imagined that the shock was not a slight one. Imagination under such conditions can easily turn the little shock into a big one, and bring about the results of a big one.

The stamping of the diaphragm, while no other injury to the instrument ensued, if done by the lightning discharge, is most rationally accounted for as follows:

The entire telephone apparatus is provided with a serrated-plate arrester outside of everything, and the telephone being off the hook, the main line was continued through the telephone coil, and also through the relatively high-resistance secondary winding of the transmitter induction coil, these together having a fairly high impedance.

But a spark gap in a branch to earth or return conductor, followed by an impedance, forms a "Lodge" lightning arrester, and is a first-class protector.

What probably happened then, was this: The discharge occurred, and a portion only thereof traversed the telephone wire; being an oscillatory discharge of high frequency,

* The mistake was due to the engraver. As corrected, the cut is used in the letter of Mr Sanborn, his sketch and that of Mr. Putman being identical in principle.—ED.

it was first dammed back by the impedance of the core-encircling coils, and the major part of the portion carried by the wire jumped the points and passed to earth harmlessly.

If the man was touching the screw posts, he would probably get a taste of this. But the discharge would not all go off as a spark; a portion would pass through the coils to earth, and though the transient current produced thereby, was so weak that it did not burn out the coils, it was swift in action, and would make a surge through the telephone coil strong enough to greatly emphasize the core magnetization for an inappreciably brief instant of time; and the diaphragm would thereupon be suddenly and violently pulled towards the core with a sharp and irresistible force, with the result stated, of stamping it as though in a die.

The extreme swiftness of the mechanical action of lightning is well exemplified in cases which are known, of cotton-covered wires in the path of a discharge, which have had the copper conductors crushed to impalpable dust within the covering which has remained unharmed.

Boston, Mass. T. D. LOCKWOOD.

"Double-End" Switch Arrangement—Dynamo Bell Ringing—Strengthening Magnets.

To the Editor of American Electrician:

In carefully looking over the drawing submitted by Mr. J. E. Putnam in the September issue, I must confess that I am unable to see any difference between the method there presented, and the original method given in the August issue. There are one or two errors* in the drawing, which is reproduced herewith (Fig 1), as I understand it is to be made, the wires being divid-

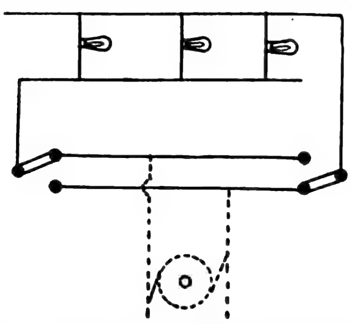


FIG. 1.—"DOUBLE-END" SWITCH ARRANGEMENT.

ed at the right of the lamps, instead of coming together as in Mr. Putnam's sketch. The switches should also be shown on one or the other of the points, for they are never to be left off of both as in the September sketch. The method of connecting to the main leads is not shown, but it is presumed to be as shown by the dotted lines. Given these necessary changes, can there be found any difference in the arrangement of the two methods? Do not both the feed wires go into each switch in both instances? As for short circuits, I can see no more danger therefrom, than in any electric wiring. When the lamps are not burning, they are in shunt with one or the other of the main loads, depending for choice upon which way the switches chance to be thrown.

*The errors were made by the engraver.—ED.

To change the subject a little, I will ask Mr. Putnam, or ony other of the "craft," to send to the AMERICAN ELECTRICIAN, a sketch showing how to connect up a lot of lamps in this manner, using a three-wire circuit, and not only having the lamps so that they can be turned on or off at the extreme points of the service, but have it so arranged that the lamps can be turned on or off at any point where a switch may be put in, say at *b* and *c* (Fig. 2), as well as at *a* and *d*.

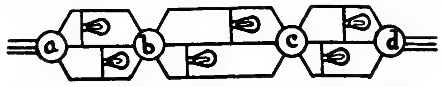


FIG. 2.—THREE-WAY "DOUBLE END" PROBLEM.

The substitution of secondary for primary cells in the scheme for "Dynamo Bell Ringing," as proposed by Mr. Chas. E. Lee may, as he states, be more "up to date," but before taking out the primaries, I would like a little more information regarding the probable behavior of the secondary cells, the bell contacts, and those of the push buttons under the conditions imposed by Mr. Lee's method.

The four cells shown of storage, or "secondary" battery are connected in series with a lamp, to the mains of a 110-volt circuit. What w ll be the behavior of the cells exposed to a voltage of 110, and fed with a current of less than three-tenths of an ampere? The current will surely be less than this, for the lamp has a resirtance of not less than 330 ohms, and added to that, are the 8 or 10 volts of counter E. M. F., from the secondary cells.

Again, how would the contacts of bells and push buttons stand this current? In Corson's arrangement, I should adjust the bells to ring by the battery current, then increase the resistance (*g*, in diagram of Dynamo-Bell Circuit, August issue), until the current was cut down sufficiently to allow the contacts to stand up under the heavy voltage. If Mr. Lee does this in his plan, he is still further cutting down the charging current of the secondary cells, and making it more problematical to me as to how the storage cells are to behave. If he does not cut down the current in this matter, the bells get the whole of it, and as they are low-resistance concerns, I am afraid that there would be a boom in the market for platinum contacts before many days.

In the reply to a question (page 371, September issue) in regard to strengthening a horse-shoe magnet, the querist is advised to place the magnet across a dynamo pole-gap, or to lay on pieces of iron if the gap is too wide, and place the magnet on the pieces of iron. This will strengthen the magnet all right, but it should be a standing rule in every dynamo room, *never* to bring any iron around a dynamo that is in operation. It is bad enough to have to present an occasional wrench to the machine, and as for the loose pieces of iron and the magnet, just *don't*.

In this connection, I will relate the experience of one man who tried to "show off" a motor by using pieces of iron for that purpose. It was in a printing office. The owner was very proud of the new machine, and took to see it everybody that chanced to visit the office. One day, a man who was posted happened to be shown the motor by the proprietor, and, to make the visit interesting, he picked up a small handful of shingle nails from a window sill near by, and made a motion to throw at the motor. The owner jumped to prevent what he supposed would cause great mischief, but the visitor did throw them, apparently so carelessly, yet with such nice calculation, that the nails all struck the pole-pieces, and there they stood, sticking straight out endwise from the iron. As soon as the owner recovered from his consternation, he thought the trick a good one, and mentally made arrangements to try it himself at the earliest opportunity.

The next day, a party of half a dozen, ladies included, were looking at the motor, and the owner determined to try the new trick. Not finding any more nails at hand, he reached his hand into the "hell-box" which stood nearby, and threw a dozen pieces of old type directly into the motor. Some of the pieces struck the armature and were dragged in between the fields. There was a snap, a bang, and a scramble on the part of the visitors, to obtain a proper distance from that motor as soon as possible. After a vivid display of pyrotechnics for a few seconds, and a noise like the discharge of a young Gatling gun, the motor finally stopped in a cloud of smoke and dust.

The armature had to be rewound, the shaft was bent, and the pole pieces sprung, but one printer had taken an object lesson in electricity and magnetism which he will not forget in a hurry. Now he knows that iron and steel are magnetic, while type metal, which is made of lead and antimony, is not magnetic in the least.

I am afraid that the man who tried to strengthen a magnet on the pole-pieces of a generator, might come out as poorly as the printer. It would be safer to put one leg of the magnet into a helix for a few seconds. A quick way to do it is to disconnect one of the lamp leads (arc or incandescent) and after winding a bit of the same size of wire around one leg of the magnet, loose enough to come off easily, connect the coil thus made into the socket the line wire came out of, and also connect it to the line with a wire clamp. Put a piece of iron, bent like the magnet, into the helix, and let current pass. Present the magnet to the bit of iron, and note which leg is attracted by the iron in the helix. The one *not* attracted is to be put into the helix after the iron has been removed. JAMES L. FRANCIS.

Brooklyn, N. Y.

ELECTRICAL CATECHISM

160. Why do many writers on alternating currents use so many diagrams with circles and triangles?

These are generally used to explain or to determine the relations between the various currents and electromotive forces that must be considered in discussing alternating-current problems. With continuous currents,

the relations between current and E. M. F. are very simple, but in dealing with alternating currents and E. M. Fs., one may be at its greatest value at a time when another is at its zero or any intermediate value. When, for example, the current and E. M. F. do not reach their highest values at the same time, as in Fig. 1, the watts cannot be determined by simply multiplying current by volts, since that would give too large a result. By the use of geometry, we can easily determine the part of the E. M. F. which is in phase with the current, and can then get the watts by multiplying the current by that part of the E. M. F. To do this, we must know how to resolve the whole E. M. F. into its elements. By a simple geometric method, we can find what will be the result of adding two or more E. M. Fs. or currents that have any difference of phase. By reversing the same process, we can take any E. M. F. or current and find what two or more elements might have been combined to make it, or if we

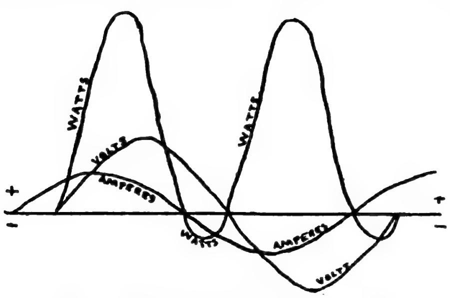


FIG. 1.—CURRENT AND E. M. F. OUT OF PHASE.

know one of the elements we can easily find the other. This process is an application of what is generally called "the resolution of forces."

161. How can the resultant of two or more forces be determined graphically?

The forces may be represented in direction and amount by straight lines drawn in suitable directions and of such length as to represent to any convenient scale the amount. For example, let *A* and *B* in Fig. 2 represent two horses pulling in the directions shown, the length of the lines representing the strength with which each horse pulls. Then their combined pull equals that which might be given by a third horse pulling in the direction, *C*, and to the amount indicated by length of line *C*. The direction, *C*, is found by drawing lines through *A* parallel to *B* and through *B* parallel to *A*. The line drawn from the intersection of *A* and *B* to the intersection of the lines parallel to them represents in direction and in amount the resultant. When there are more than two component forces, these may be combined in pairs and the resultants of the pairs may then be treated as components. It is clear from the last figure at the right that if the two component forces are in exactly the same direction, their resultant is in the same direction and equals their arithmetical or algebraic sum. But if the component forces are not in the same direction, their geometrical or trigonometrical sum must be taken. For example, in the figure at the left of Fig. 2, if *A* and *B* were in the same direction, their sum would be *o c'* as shown in the lower part of the figure instead of the smaller resultant, *o c*.

162. How can a force be resolved into its components?

The simplest way is by geometry or trigonometry. Any force or resultant may be resolved into any desired number of compo-

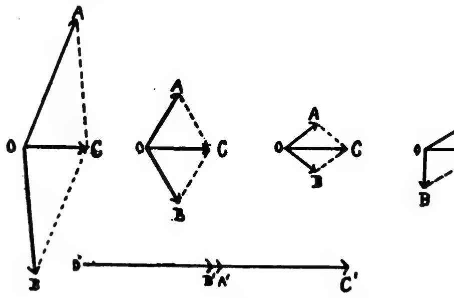


FIG. 2.—PARALLELOGRAMS OF FORCES.

nents and any or all of the components may be equal to or greater or smaller than the resultant, as seen in Fig. 2. There may be any number of pairs of components derived from any one resultant, and it is necessary to fix certain conditions if one is to obtain a definite desired pair. Since each resultant is determined by its length and direction, each solution involves two directions and two lengths. If both lengths are given, or both directions, or one direction and one length, the solution is easy.

163. How can the components be determined when their directions are known?

Draw the resultant first, as *O C*, of Fig. 2. Then from *O* draw lines in the proper directions, but of indefinite length. Then from *C* draw lines parallel to *O A* and to *O B*. The points where these cross determine the lengths of *O A* and *O B*. This problem has only the one solution.

164. How can the components be determined when their lengths, but not their directions, are known?

Draw the resultant, *O C*, first, as in Fig. 3. From each end as a center draw two circles, each with a radius equal to one of the two forces. From *O* and *C* draw lines to the points where the larger circle drawn from *O* is cut by the smaller circle drawn from *C*. Draw lines parallel to these from *O* and *C* to the point where the smaller circle drawn from *O* is cut by the larger circle drawn

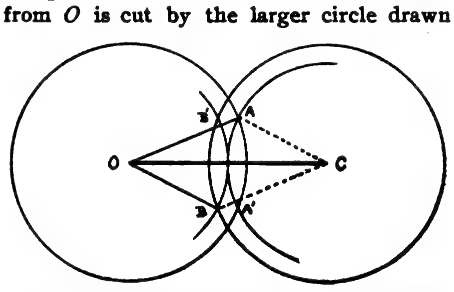


FIG. 3.—DETERMINATION OF COMPONENTS.

from *C*. Then *O A* and *O B* are the components sought. It is seen also that another solution may be had by drawing a parallelogram on *O B' C A'*, so that this problem has two solutions, unless the two components are equal.

165. How can the components be determined when the direction of one and the length of the other are known?

Draw the resultant *O C*, as in Fig. 4. From *O* draw a line of indefinite length in the known direction of one force. From *C* draw a circle with a radius representing on the proper scale the known force. Draw a radius from *C* to the point where the circle crosses the line. From *C* also draw a line parallel to *O A*, and from *O* draw a line parallel to *C A*. Then *O A* and *O B* are the two components desired. It is seen that the

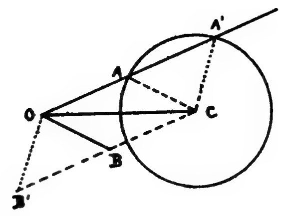


FIG. 4.—DETERMINATION OF COMPONENTS.

line may cut the circle in two places, giving the second parallelogram *O A' C B'* and the two components *O A'* and *O B'*. If the line does not cut or touch the circle at all, there is no solution.

166. Of what value is this geometry for studying alternating currents?

It enables one to solve many problems that otherwise would be very difficult. For example, if one knows the amperes, volts and angle of lag, it is easy to determine the watts graphically or by a geometric method similar to the above. Or, knowing the amperes and angle of lag between the voltage and current, it is easy to determine the amount of the wattless component of the current.

167. How can one determine the wattless component of the current when the angle of lag is known?

This may be determined by the method given in No. 162. The current is to be resolved into two components, one representing the active current in phase with the E. M. F., and the other representing the wattless current at right angles or 90 degs. behind it. From any point, *O*, taken as the origin, draw (as in Fig. 5) an indefinite horizontal line, *O X*, representing the E. M. F., and the direction of the active component of the current. From *O* draw another line making an angle, *C O X*, with *O X* equal to the angle by which the current lags behind the E. M. F. Lay off a distance, *O C*, on

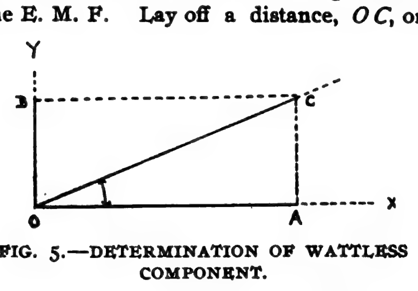


FIG. 5.—DETERMINATION OF WATTLESS COMPONENT.

this second line which shall represent on a suitable scale the total current. Now it is desired to resolve *O C* into two components, one of which shall be in the direction *O X*, and the other at right angles to it. From *C* draw a line, *C B*, parallel to *O X* and another line perpendicular to it. Draw a perpendicular line, *O Y*, from *O*. Then we have the parallelogram of forces, *O A C B*, and the components of *O C* are *O A* and *O B*. In other words, *O C* represents the actual current flowing, *O A* is the component of it which is active or in phase with the E.M.F., and *O B* is the wattless component.

QUERIES AND ANSWERS

NOTE. *Criticisms and extensions of the answers given in this column will be welcomed. Windings of amateur motors and dynamos cannot be supplied, as such designs rarely justify the labor required for the calculation; the complete series of designs of small machines now being published in this journal will usually furnish data for other small machines, if intelligently applied.*

What color does iodide of potassium paper turn in testing for polarity? H. A. B.

The positive pole is designated by its leaving a brown mark.

How is hair removed by electrolysis? H. J.

We cannot take the responsibility of answering questions relating to the application of electricity to the human body.

How can a 220-volt motor be transformed for use on a 110-volt circuit? H. V. D.

Connect the fields in parallel; also connect the armature coils in parallel, throwing out every alternate bar to do so, and short-circuit such bars on the respective adjacent bars.

1°. Will the motor described in the February issue run as a dynamo with malleable iron fields and pole-pieces? 2°. Will soft sheet punchings be good enough for the armature? 3°. At what speed should the machine be run as a dynamo? G. S. B.

1°. Not satisfactorily. 2°. If special low-carbon steel, yes; otherwise charcoal iron must be used. 3°. 2500 revolutions.

What is the standard wire gauge in this country? Our city elect ician uses the "Standard" gauge. C. L. B.

The Brown & Sharpe or American gauge is the standard in this country; the "Standard" gauge is the legal gauge of Great Britain, where the Birmingham gauge is also used.

1°. Where can I purchase a good quality of calcium tungstate, and at what price? 2°. How much is needed to make a 6 in. × 6 in. Röntgen screen? H. J. E.

1°. From Merck & Company, University Place, New York; the price is ninety cents per ¼-oz. vial, including postage. 2°. Screens have been made from ⅛ oz., but usually at least ¼ oz. is used.

What is a safe current for a No. 10 German-silver wire used in exposed coils in a rheostat? H. A. B.

The resistivity of German-silver wire varies greatly owing to differences in composition; if 2. 2 times that of iron, a safe current with coils in a wood frame would be 8 amperes; in iron frame 10 amperes; for one minute, 20 amperes.

How may a Bell receiver magnet be remagnetized? F. L. S.

Put the magnets in a coil of the largest number of ampere-turns available; that is, the product of the turns in the coil by the amperes flowing. Before entering the magnets, note which end is attracted by one end of the coil, and enter the attracted end of the magnets into that end of the coil.

Why is a low-frequency transformer larger than one of high frequency? S. T. L.

For the same reason that a slow-speed dynamo is larger than a high-speed one. A transformer generates secondary E. M. F. by the cutting of lines of force as in a dynamo, the speed of cutting corresponding to frequency in the former case and to revolutions in the latter.

In a 130-volt plant when the positive side of the voltmeter is connected to ground, the reading is 113 volts. If there were a good ground on the other side of the dynamo, would it involve a short-circuit? F. G. F.

The first-mentioned ground must be of high resistance to produce a drop of 130 − 113 = 17 volts; for, since the voltmeter current flowing is very small, R in the formula, drop $= C R$, must be far from a short circuit.

How may the sp.ed of a 5-HP shunt motor be considerably reduced? W. I. M.

If the fields are not saturated, rewind them, if space will allow, with a larger wire, but using the same number of turns—at any rate, increasing the ampere-turns; also, place a resistance in the armature circuit. Both of these methods will reduce the efficiency of the motor, but otherwise it will be necessary to rewind the armature, using a less number of coils.

I have a number of differential series arc lamps designed for 6½ amperes at from 42 to 44 volts; can these be run ten in series on a 500-volt circuit, or two in series on a 110 volt circuit? E. S. V.

Ordinary differential-arc lamps will not work on constant-potential circuits, and can seldom be changed to do so. If the construction is such as to allow the substitution of a coil spring for the series magnet, leaving the shunt coil to do all of the magnetic regulating, the lamps may be made to work two in series with a resistance of 1½ ohms on a 110-volt circuit. Ten lamps will run in series on a 500-volt circuit.

What is the meaning of the term "power factor"? J. A. T.

The power factor is the ratio of the watts to the volt-amperes, or the ratio of "useful" current to the entire current flowing, in an alternating-current circuit; the entire current being the sum of the "useful" and so-called "idle" currents. It is also the cosine of the angle of lag between the current and E. M. F. The greater the reactance of the circuit the larger the power factor. In practice the reactance usually consists of inductance alone, since the effects of capacity are ordinarily small.

What is the duration of a spark from a condenser and from an induction coil, respectively? S. R. B.

The duration of the spark depends upon the vibrator adjustment (frequency), the capacity resistance and inductance of both the primary and secondary circuits. Lucas and Cazin found that the discharge of two Leyden jars occupied .000026 second, and that as the capacity of the circuit was increased to eight jars, the duration of the spark increased to .000047 second. The discharge of an induction coil would be of longer duration because the demagnetization of the core is not an instantaneous process.

1°. What is the lag or power factor of a lamp and a motor load? 2°. Knowing the power factor, how is it applied? J. H. C.

1°. For a lamp load it may be 90 per cent. or more, depending upon the amount of current, length of circuit, the arrangement of line wires, frequency, etc. For a power load it may fall as low as 70 per cent., depending upon the design of the motors, their loading, and the above line factors. 2°. Take voltmeter and ammeter readings, multiply them together and multiply the product by the power factor, which will give the watts; dividing by 746 will give the horse-power.

Will a dynamo with a Siemens shuttle armature having a two-segment commutator and a pair of collector rings, run as a motor on an alternating-current circuit and deliver a direct current from the commutator? R. O. B.

Assuming first that it is gotten into synchronism and then runs as a motor, the two-part commutator would deliver a current consisting of flat-topped waves, varying from zero to a maximum and back to zero. To get the motor into synchronism it would have to be speeded up to a speed per minute equal to half the number of alternations per minute, or 8000 r. p. m. with the usual lighting current, which would be practically impossible.

What is the carrying capacity of No. 14 copper wire? J. G. K.

A wire has no definite carrying capacity up to the fusing point, and its rating in this respect depends upon its use. A No. 14 wire will be fused by about 175 amperes. In open air the temperature of the same wire covered with black insulation will be 72 degs. F. above the atmosphere when carrying 45 amperes; 36 degs. when carrying 25 amperes; 18 degs. when carrying 20 amperes, and 9 degs. when carrying 15 amperes. In moulding, with 9 amperes the temperature, according to Kennelly, will be elevated 18 degs. The new underwriters' code permits 12 amperes to be carried by rubber-covered wire and 16 amperes by weather-proof-covered wires. There are still other figures when the wire is used in armatures and in field magnets. The general misconception concerning carrying capacity is probably due to confusing it with size of wire as fixed by considerations of drop, between which there is no direct relation.

What are the latest underwriters' requirements as to the carrying capacity of wires? P. N.

The requirements of the new "National Electrical Code" are as follows:

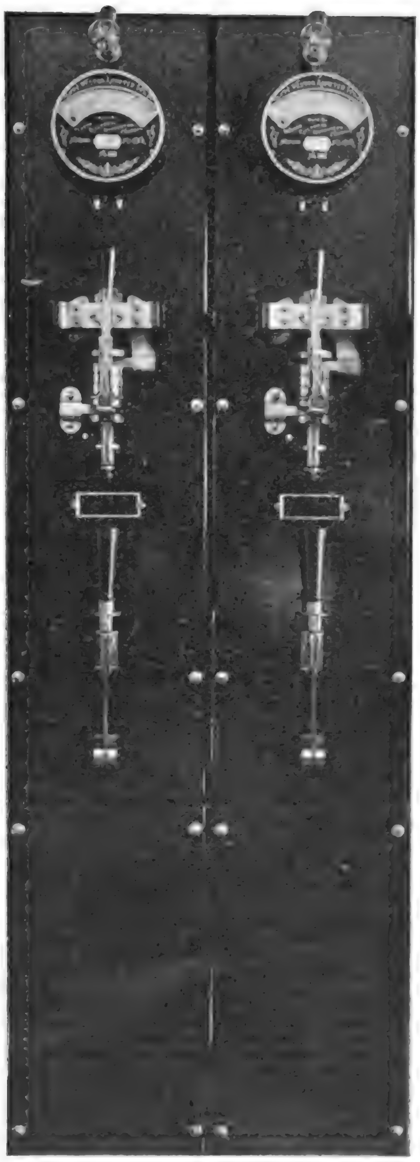
B. & S. Gauge.	Amperes.	Amperes.
18	3	5
16	6	8
14	12	16
12	17	23
10	24	32
8	33	46
6	46	65
5	54	77
4	65	92
3	76	110
2	90	131
1	107	156
0	127	185
00	150	220
000	177	262
0000	210	312

The second column refers to rubber-covered wire; and the third column to weather-proof wire. The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires. The question of drop is, of course, not taken into consideration in the above tables. The carrying capacity of 16 and 18 wire is given, but no smaller than 14 is permitted to be used, except in special cases. The wire must be not less than 98 per cent. pure copper.

New Apparatus and Appliances.

ELECTRIC-RAILWAY SWITCH-BOARD PANELS.

In the manufacture of electric-railway switch-boards a system of so-called "panel construction" has now been generally adopted for both feeder and generator service. According to this system, boards are built in vertical sections or "panels," each section, or panel, constituting a unit in itself and providing for the complete control of one generator or one feeder. The building up of a switch-board for a given number



SWITCH-BOARD PANELS.

of generators or feeders, accordingly, consists simply in the erection, side by side, of a corresponding number of generator or feeder standard panels. Each panel is provided not only with all devices necessary to its operation as an independent unit, but also for ready coupling to other panels for combination service upon a common bus-bar or set of bars into which the current supply is sent or from which it is taken. This form of construction makes it entirely optional with the purchaser as to how his switch-board is erected. He may have his generator panels and feeder panels at both ends, his generator panels at one end and feeder panels at the other, or he may have entirely independent generator and feeder boards.

Two panels of this type are illustrated herewith. The panel body consists of black japanned, highly polished slate, 2 ins. in thickness. This slate is carried on substantial angle irons permanently secured to each vertical edge, which are so drilled that in the erection of panels side by side, the adjacent angles may be fastened together to form a T. For bracing, there are tie rods, which may run to the rear wall. Bus-bars are carried by heavy cast-copper terminals directly on the hinge-post studs of the feeder switches. These bus-bars are built up of drawn-copper sections, either of round or oblong section, the number of sections used being proportioned to the service of the board. The standard section is oblong, this more readily permitting the doubling up of capacities as desired.

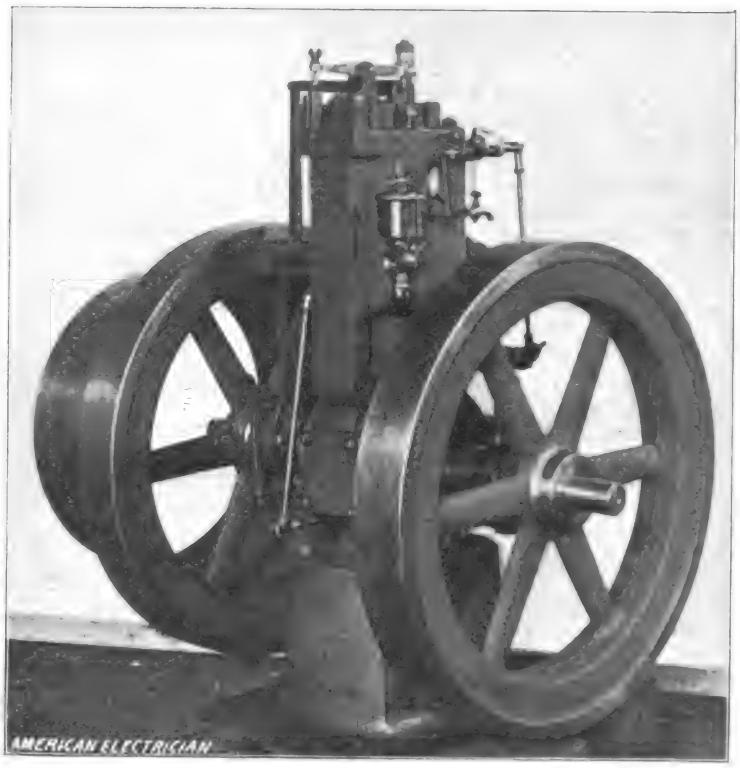
The panels shown in the illustration, the height of which is 90 ins., are for 600-ampere circuits each. Each panel has a 1000-ampere Weston round-type ammeter, a 600- to 1000-ampere circuit breaker, and a single-throw switch. The switch is of the carbon-break type, the contact being broken on a carbon point, which follows the knife as the switch is opened, thus effectively preventing burning of the contact tips.

This type of switch-board panel is made by the Wagner Electric Manufacturing Company, St. Louis, Mo.

WOLVERINE ELECTRIC-LIGHT GAS ENGINE.

The accompanying illustration shows one of the latest types of the Wolverine model electric-light gas engine. This engine is designed especially for electric lighting or other purposes where regular power is demanded. It gives an impulse at every revolution of the crank, has extra heavy fly-wheels and runs at high speed. The charge is controlled by a governor which, in regulating the quantity of the charge and not varying the quality, still enables the engine to give an impulse at every revolution under varying loads, thus ensuring regular motion with a minimum quantity of fuel. The engine is extremely simple in construction, having practically but two running parts, and no valves requiring constant oiling. The engine is adapted for either electric or heat ignition of the charge. With either method, there is no fire or electricity used as long as fuel is supplied, except, of course, in starting the engine. Being vertical, the engine requires less space and weighs less, probably, than any other type of engine made.

This engine is well adapted for all purposes where economical power is desired. It is also manufactured for marine use, the marine type having a low base and one small fly-wheel. These are made reversing and self-starting, the same as in the case of a steam engine. The center of gravity is very low in the boat, thus causing the engine to act as ballast. These engines are manufactured by the Wolverine Motor Works, Grand Rapids, Mich.



WOLVERINE GAS ENGINE.

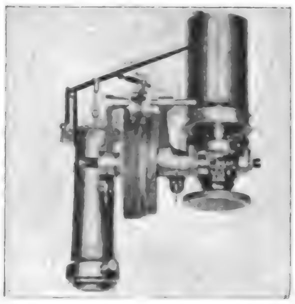
THE "BUFFALO" REDUCING WHEEL.

The reducing wheel shown herewith requires no tools, wrenches or screw-drivers in its adjustment, it being set up, in fact, like an indicator and works the same way; that is, in any direction by simply a thumb and hand adjustment, and smoothly and noiselessly at all speeds.

The main cord-wheel and the change spools are made of aluminum; the arms and

spring case of brass nickel-plated. The wheel complete weighs but 16 oz. and can be carried, spools and all, in the pocket. It is nevertheless strong and substantial, and is suitable for strokes up to and including 72 ins. The entire thrust of the shaft is received by a pivot, thus reducing the friction.

As the spring and spring case do not revolve, the momentum is reduced to a minimum. Enclosed in a spring case is a light spiral spring which returns the cord-wheel; this spring is adjusted for tension by unclamping the thumb-screws, turning the spring case by means of the knurled ring, then clamping the arms in the position desired. The cord-wheel is of small diameter, only 2⅝ ins., and engages with the spring at the hub;



INDICATOR REDUCING MOTION.

the pull is thus made direct through the wheel to the spring, and is not transmitted to the other bearings, thus reducing friction and chance of breaking. The motion is then carried through the worm to the adjustable change spool. At this point adjustment is made for stroke by selecting the proper size of spool and slipping it over the spindle, then clamping it with a knurled nut. As the spools are marked for the strokes for which they are best suited, no calculation is necessary. After selecting the spool marked with the proper stroke and putting it on, the indicator cord is connected to the spool, then the cord wheel to the cross-head and the operation is complete.

Spiral winding is obtained by the movement of a nut and arm over the end of the shaft, giving an outward and inward feed to the swivel pulley, which is universally adjustable. The tension, when connected to the indicator, is but a trifle stronger than that of the indicator alone.

The attachment is made to fit any indicator. Four spools are furnished with each wheel. The cut illustrates the indicator and wheel tipped back to show the worm, but otherwise does not give a very clear view.

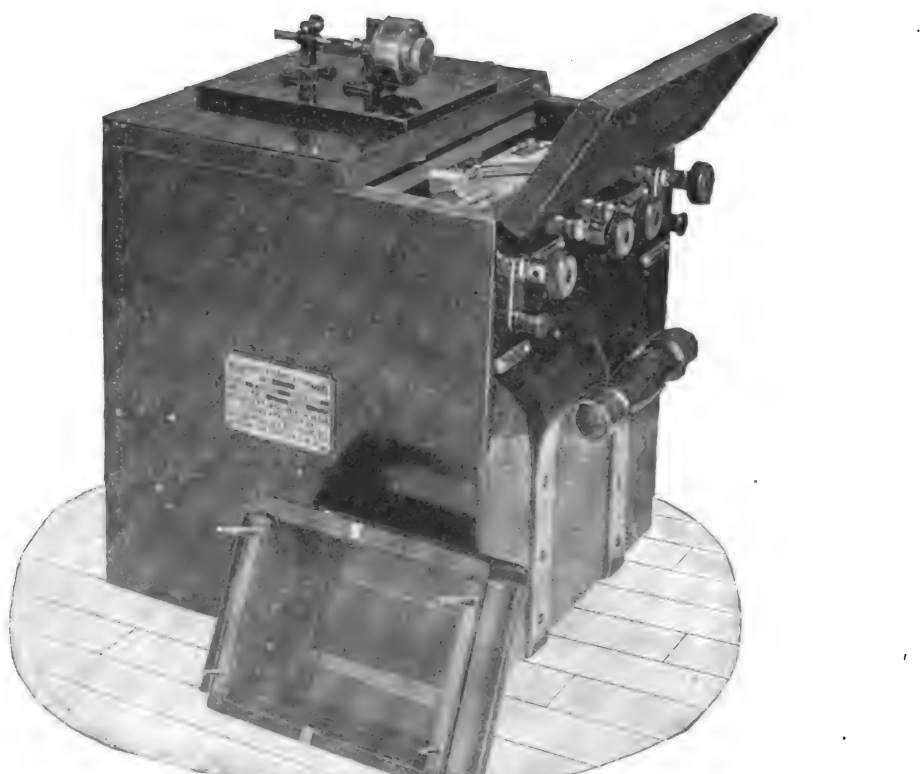
The manufacturers are the Buffalo Indicator Company, 55 Lakeview Avenue, Buffalo, N. Y.

HIGH-POTENTIAL TESTING TRANSFORMER.

The 10,000-volt, high-potential testing transformer shown in the accompanying engraving, consists of a small transformer wound on a rectangular core similar in construction to that of the "Type H." The low-tension circuit is wound on one branch of the core, and on the other branch the primary coils are placed. There are four primary coils, each wound and insulated independently, the four coils being assembled on a sleeve of heavy insulating material. After assembling, each transformer is tested to a maximum strain of 35,000 volts between the high- and low-potential windings, thus insuring safety from accident. By means of a porcelain series-multiple connection board, the apparatus can be used on either 52- or 104-volt circuits. The transformer itself is immersed in oil.

On the top of the apparatus is a box with a glass window, enclosing a micrometer spark-gap arranged as a shunt across the high-potential terminals. This box or cover contains four long contact studs fitting into sockets in the transformer box. The lifting of this cover for the purpose of adjusting the spark-gap entirely disconnects the spark-gap from the high-potential circuit. On one side of the transformer case are six terminals, two for the main circuit, two for the adjusting rheostat, in series with the low-potential circuit, and two small terminals providing connections for the voltmeter permanently across the low-potential circuit of the transformer. The transformer case is of mahogany, and the trimmings of nickeled brass and polished hard rubber. The case is provided with two handles for transportation, also with a stop-cock for drawing off the oil when necessary. Provision is made for readily polishing and readjusting the points of the spark-gap.

When using the apparatus the spark-gap is first set to discharge at the limit of voltage desired, which is readily done either by the use of a calibration curve or by a voltmeter on the low-potential circuit, the ratio of transformation being known. Having



HIGH-POTENTIAL TESTING TRANSFORMER.

adjusted the spark gap, the apparatus under test is connected to the high-potential terminals on the spark-gap base and the potential again brought up to the amount desired and held as long as necessary. The apparatus under test is then connected in multiple with the spark-gap, and the accidental application of higher voltage than was intended will merely result in the formation of an arc across the spark-gap, short-circuiting the apparatus under test and protecting it from damage. The transformer is designed to run on either 60- or 125-cycle circuits, and to deliver up to 10,000 volts at a normal current of .05 ampere in the high-potential circuit. This can, however, be exceeded for shorter periods.

The rheostat used to control the voltage on the low-potential side may be of any convenient type. A small rheostat of portable form for this purpose has also been developed by the General Electric Company, the maker of the taansformer described. This consists of a vertical tube and stand with a fixed contact plate at the bottom and another plate attached to a sliding rod, the rheostat being filled with water, to which a small quantity of salt or soda has been added.

COMMUTATOR COMPOUND.

The cut herewith illustrates a stick of Holm's tesoline, a commutator compound. This compound, it is claimed, contains three

COMMUTATOR COMPOUND.

times the quantity of other makes; also that it will prevent, absolutely, all sparking and cutting of the commutator, without in any way gumming the brushes. By its use a great economy in brushes is claimed to be effected, as after a few applications it tends to give the commutator a bright finish and thus lessen friction. The Boiler Expurgator Company, 115 Dearborn Staeet, Chicago, is sole selling agent for this compound.

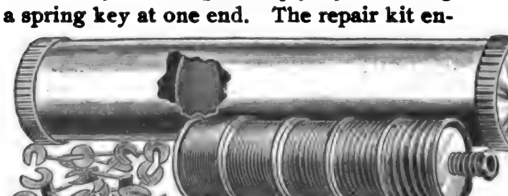
HAND-POWER DYNAMO.

The hand-power dynamo shown herewith will light a 10-CP, 10-volt incandescent lamp, or furnish current to run several electrical toys simultaneously, to fire blasting fuses or for experimental purposes, such as decomposing water, electroplating, etc. As will be seen, the armature is run through a gearing which gives it a high velocity. The finish of the machine is neat, being mounted on a hardwood base and nicely painted. The shaft is of tool steel and the bearings are babbitted. This efficient little machine is made by the Carlisle & Finch Company, 828 West Sixth St., Cincinnati.

HAND-POWER DYNAMO.

FUSE-WIRE REPAIR KIT.

The fuse repair kit shown herewith is a convenience that will be appreciated by the electrician. It is substantially made of brass tubing, finely nickel-plated, with screw caps, and with a bottom placed about one-third the distance from one end. In the short end are placed fuse-links, assorted, as may be desired. The long end accommodates a magazine containing five sizes of fuse-wire, each on a separate spool and which may be charged simply by removing a spring key at one end. The repair kit entire, loaded, weighs one pound, which is the weight of one ordinary spool of fuse-wire.



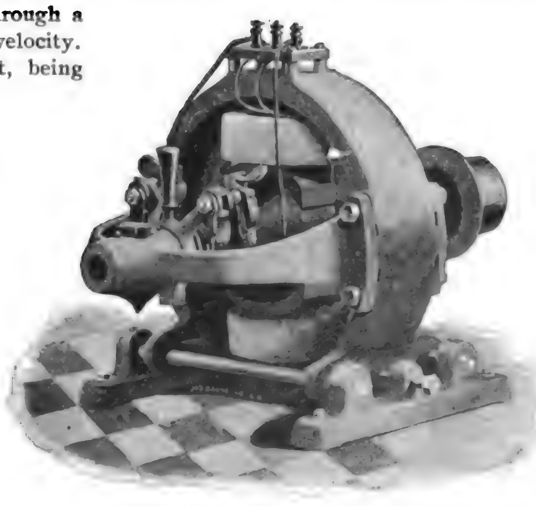
FUSE-WIRE REPAIR KIT.

The benefits to the line-man and repair-man, of this holder will be apparent at once, as it enables him to carry small amounts of a number of different sizes of fuse-wire; also an assortment of fuse-links, and all contained in a receptacle which is at once convenient and light, and which prevents the fuses from becoming damaged when thrown together with tools, etc., in the tool bag.

This device is made by the Chicago Fuse Wire & Manufacturing Company, 154 Lake Street, Chicago, and 853 Broadway, New York, which has applied for a patent on it.

A NEW "COMMERCIAL" MOTOR.

We illustrate herewith a new dynamo and motor designed to supply the demand for a highly efficient high grade machine at moderate cost, for small isolated lighting plants or for driving light machinery, such as ventilating fans, ice-cream freezers, or small machine shops. The motor is both compact and convenient to install on account of the novel method of mounting it, which consists in providing a pair of rods attached to substantial skids, on which the frame of the motor slides and is adjusted by means of a screw, providing a ready means of tightening the belt.



NEW "COMMERCIAL" MOTOR.

The bearings can be inverted so that the motor may be suspended from the ceiling if desired, and does not require any platform, which reduces the expense of installing in this manner as well as making a neater and more substantial outfit. The magnet frame is of cast steel, with circular cores for the field coils and pole shoes or extensions of such size and shape as to give the best distribution of magnetism and the greatest possible efficiency of the magnetic circuit. The bearings are heavy, self-oiling, and lined with phosphor-bronze sleeves. The commutator is large and is made of the best tempered copper and has a simple carbon brush holder, very easy of adjustment, so that the wear of the working parts and the attention required are reduced to a minimum.

This new type of machine is made by the Commercial Electric Company, Indianapolis Ind.

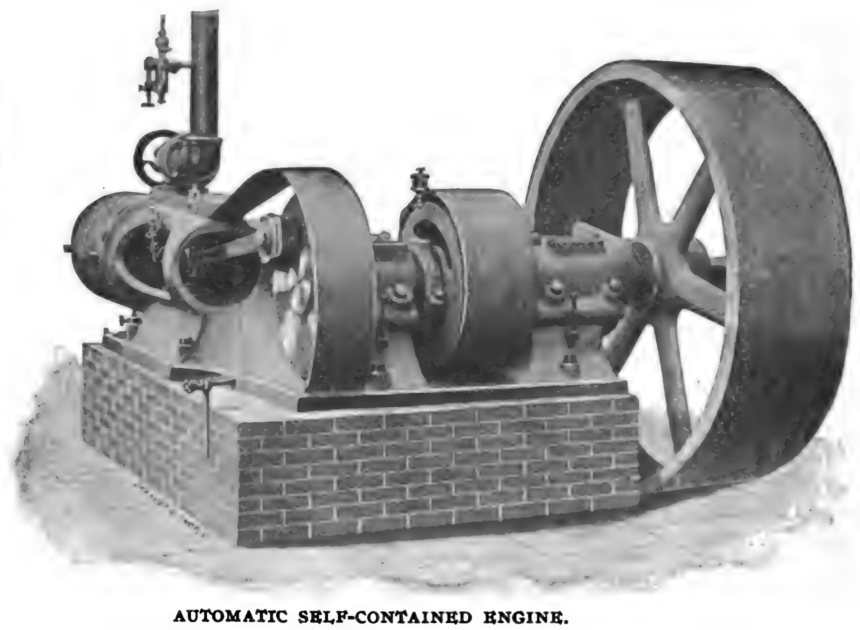
NEW AUTOMATIC ENGINE.

The engine which we illustrate herewith is a recent design in which are embodied the very best principles in engine design and construction which years of experience have suggested to the makers. The point kept in view has been to produce a machine of the highest grade and capable of fulfilling the most exacting requirements of modern engine practice.

The most careful attention has been given to the control of speed and regulation, and to this end the Rites governor has been adopted in such a form as not only to regulate an unusually high degree, but also to be capable of the most rapid adjustment with entire absence of instability or surging. The makers state that while they claim no special excellence over any other manufacturers licensed under the Rites patent, they are, however, the first who have been able to make and operate a high class of governor to meet modern requirements, and which at the same time can be placed in such a small compass as to permit the construction of a side-crank, self-contained engine.

This governor, as is well known, embodies both the centrifugal and inertia principles in a single weight and in the simplest possible manner. No dash-pots are needed to steady the governor under varying loads and it has only one bearing, the numerous joints so troublesome in most shaft governors being entirely dispensed with and the mechanism reduced to the fewest possible number of parts. By altering the tension of the spring of the governor without changing the weight, the speed of the engine can be varied to a greater degree than has heretofore been considered possible.

The self-contained design of bed used with this engine greatly reduces the cost of setting up, as both of the main bearings, are part of the main bed-casting. Furthermore, this special design of governor permits its being used between these bearings and it is thus unnecessary to remove the governor in shipping. When an engine is delivered, the purchaser has only to adjust the shaft parallel to the shaft it is to drive, put on the driving wheel, make the steam connec-



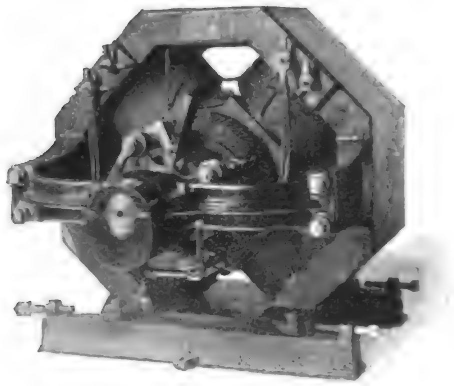
AUTOMATIC SELF-CONTAINED ENGINE.

tion and the engine is ready to run. The new type of engine illustrated is made by the Chandler & Taylor Company, Indianapolis, Ind.

THE ROTH MULTIPOLAR DYNAMO.

The accompanying cut illustrates a new type of multipolar dynamos and motors recently designed and placed on the market, which embody all the latest advances in dynamo construction as well as a number of special features of merit.

The armature is of the hollow-drum type, the core being built on a cast-iron hollow



ROTH MULTIPOLAR DYNAMO.

cylinder easily removable from the shaft. The core disks, varnished for insulation before being put together, are held between two solid cast-iron end plates, the clamping bolts passing through the inner space of the hollow drum. This method of construction avoids holes through the core disks, thus giving a uniform magnetic path in the armature. The armature coils are wound on a form, taped with silk tape, varnished and baked before being placed on the core. The parallel grouping of armature coils is employed, which in connection with a special system of commutator connections, greatly facilitates the repair of the armature. In case a coil has to be removed, this may be done by simply loosening the two armature connectors of which the coil forms a part; in general, in other types of four-pole machines, at least one-half or even all the connectors have to be unsoldered.

The commutator has a liberal collecting surface as well as wearing stock, and a large number of sections. Carbon brushes are used on all machines of 110 volts and over. The brush holders are of the tangential reacting type, the commutator surface moving in a direction opposite to the pressure of the springs. Each brush holder contains a number of square carbons, each pressed against the commutator by a spring. The tension of the springs may be adjusted and the carbons removed while the machine is running. These brush holders are among the simplest and most efficient yet devised.

The field frame is of the radial, external-pole type, which form has met with general approval during late years. The yoke is broad and entirely protects the field coils. The field cores are of annealed wrought-iron of circular section, which combines a maximum economy in the work of winding and the material of the field coils. The bearings are self-oiling, self-aligning and provided with oil gauge and cock. All wearing parts are interchangeable.

The machines are wound either as generators or motors for 110, 220 and 500 volts, or special voltages. The generators are adapted for lighting, power transmission and electro-deposition. When intended for lighting and general distribution, they are accurately compounded and are self-regulating at constant speed. The rise of temperature of armature and field coils is well within the limit generally prescribed in dynamo specifications, and the machines are of high efficiency.

PARAGON MOTORS.

The Paragon motor, which has come into such favorable notice during the past season as a fan motor, is now being built in small sizes for general power distribution purposes,

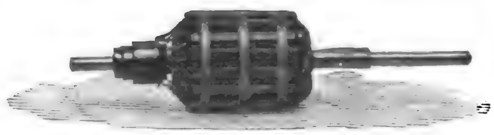


FIG. 1.—PARAGON MOTOR ARMATURE.

the capacities being $\frac{1}{12}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$ and 1 HP. These motors, as is the case with the same type for fans, are designed and made with all the care that is usually spent on large units. The general familiar features of the Paragon fan motor are embodied in these power motors, namely, iron-clad construction, enclosing everything but the pulley, with circular field and toothed armature. The new motors are made with an iron base, with the edge turned up to form an oil pan, and are fitted with radial brushes, the pressure of which is adjusted by a screw and lock nut. Owing to the excellent magnetic circuit, low air-gap reluctance, etc., the motors are of light weight and highly efficient for their size. The $\frac{1}{2}$ HP size, for example, weighs only 60 lbs. They are also made up as small-size motor dynamos for the generation of alternating currents from direct currents, etc.

FIG. 2.—QUARTER-HP PARAGON MOTOR.

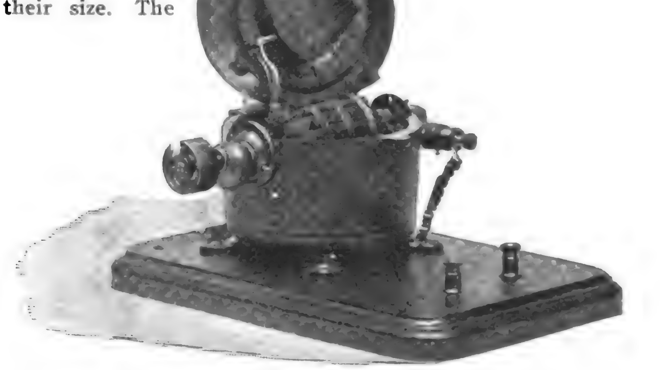


FIG. 3.—INTERIOR VIEW OF PARAGON QUARTER-HP MOTOR.

The accompanying illustrations show the type of armature, and two views of the machine complete. The Paragon motors are manufactured by J. P. Williams & Company, 39 Cortlandt Street, New York.

PORTABLE DESK TELEPHONE.

The old style speaking tubes with their many faults, have been gradually relegated to the rear, a light, neat, portable telephone being so far ahead of the tubes and practically not costing any more, that they are now almost universally used instead. A very handsome and serviceable instrument of this kind is shown herewith.

In an interior inter-communicating system where there are not more than six or eight stations or departments connected together, a number of neat push-buttons arranged at each station is unquestionably more easily

PORTABLE DESK TELEPHONE.

operated than a switch or plug system, with the added advantage of there being fewer parts to require attention.

The instrument shown stands about 12 ins. high. It is fitted with a long-distance granular-carbon transmitter, having a $2\frac{5}{8}$ in. diaphragm and a specially arranged protecting plate. The transmitter is adjustable and the wires leading to it are carried entirely within the joint. The entire instru-

ment is self-contained, there being no bells or batteries about the desk.

The illustration shows the desk telephone fitted with a watch-case receiver and push-buttons suitable for a three-station system; the lightness and the less danger of becoming broken or thrown out of adjustment makes the watch-case style of receiver especially desirable.

The above set is made by the Allen-Hussey Company, Chicago, which also makes a companion instrument in the form of an admirably arranged wall telephone.

"MIDGET" ENCLOSED ARC LAMP.

The "Midget" enclosed arc lamp for street railway circuits embodies all the essential features of simplicity of the low-tension lamp, and is furnished either with or without automatic regulation. The lamps are operated five in series on circuits varying from 475 to 550 volts. The automatic regulation, which in many places is a desirable addition, enables one or more lamps to be thrown out of circuit, resistance being cut in to take the place of the lamps. When the lamps are not fitted with this automatic

"MIDGET" ENCLOSED ARC LAMP.

regulation, they burn as one unit, and one lamp cannot be thrown out of circuit without the others in the same series also being cut out. The manufacturers state that they have these lamps operating very successfully on electric railway and power circuits.

The cut accompanying this article shows the standard lamp for 110-volt circuits. The "Midget" enclosed arc lamp is also made for high-tension series circuits, taking 4 to 7 amperes; for alternating current of any frequency from 60 to 133, to consume from 400 to 450 watts; also to burn two in series or singly on 220-volt circuits.

The Midget lamp is made by the Standard Thermometer & Electric Company, Peabody, Mass.

STAR DRY BATTERY.

The dry cell illustrated herewith is claimed to be particularly adapted for X-ray work, one cell being used for each inch of spark from an induction coil. Another feature claimed is freedom from local action, a cell

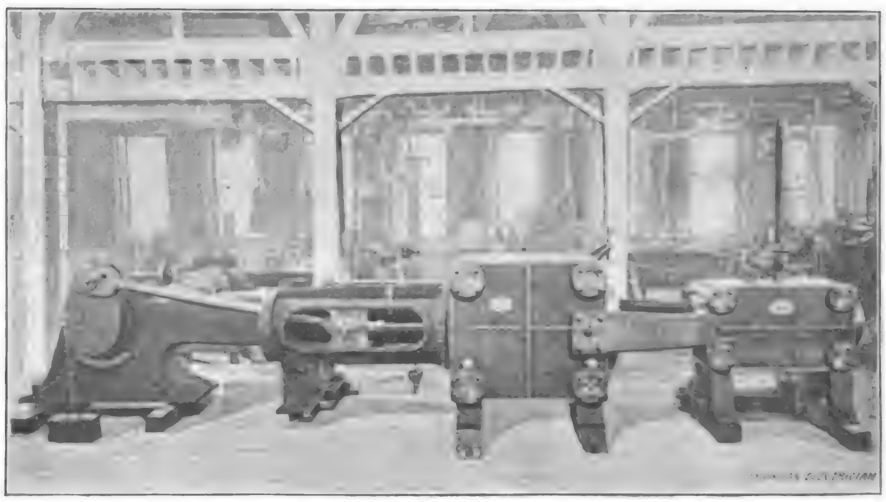
STAR DRY BATTERY.

retaining its power indefinitely when not in use. The cell is made in four sizes—the largest being 7 ins. high by 3 ins. in diameter, and the smallest, 3 ins. high by 1 in. in diameter—by the Star Dry Battery Company, 143 East Eighth Street, New York.

TANDEM-COMPOUND CORLISS ENGINE.

The tandem-compound Corliss engine shown herewith was built for the "Adler Braurei," Dortmund, Westphalia, Germany, in connection with a refrigerating machine, and also to furnish the entire motive power for the other brewery machinery in use.

The engine is constructed for 130 lbs. boiler pressure, and has the following dimensions: High-pressure cylinder 14 ins. bore, low-pressure cylinder 28 ins. bore, and 36 ins. stroke. The shaft is 11 ins. in diameter at the bearings and 14 ins. at the wheel. The frame and pillow block are cast in one piece, the frame having bored guides. The pillow block is provided with four quarter



TANDEM-COMPOUND CORLISS ENGINE.

boxes, which are adjustable by wedges and screws. The valve-gear is of the Corliss type, and so constructed that the hooks catch the blocks by their own weight, the springs only being necessary after the steel blocks are worn to some extent.

The governor is of the Watt type, provided with a weighted lever for changing the speed of the engine, and with a dash-pot and automatic safety stop. The vacuum pots are of the latest style, closed on top, and can be cushioned, thus being quick-acting and at the same time perfectly noiseless.

The engine and refrigerating machine were built by the Vilter Manufacturing Company, the well-known builders of Corliss engines and refrigerating machines, at Milwaukee, Wis. This is a case of "made *for* Germany" instead of "made *in* Germany."

MULTIPOLAR LOW AND MEDIUM-SPEED DYNAMOS.

In the design of the multipolar type of dynamo and motors shown in the accompanying illustration, the aim has been to produce a machine of high electrical efficiency without sacrifice in any respect of the properties upon which the smooth running of a machine under practical conditions are dependent.

The most particular attention has therefore been paid to all of the mechanical features—armature, ventilation, commutator, brushes and bearings, the result being a machine of slow speed and high efficiency that will run sparkless and perfectly cool under normal load, require a minimum of attendance and be able to withstand a more considerable overload than is usual with machines of the same efficiency.

Up to and including 6½ KW the frames and fields are solidly cast in one piece. For convenience in handling, in all sizes above this the frames are made of one piece and the magnet in two parts, so that the top can be lifted, thus permitting free access to the armature or field coils. The magnet yokes are made of mild open-hearth steel; in the larger sizes the magnet cores are of laminated sheet-iron cast solidly into the yoke, the faces being slotted, thus distributing the magnetism uniformly over the armature.

The armature is iron-clad type, the conductors being embedded below the surface in insulated tubes made up of mica and oil paper. In the larger sizes copper bars are used without any joints except at the commutator end. The armature coil is constructed from disks of special armature iron carefully annealed and thoroughly tested. These are built up on the armature spider in

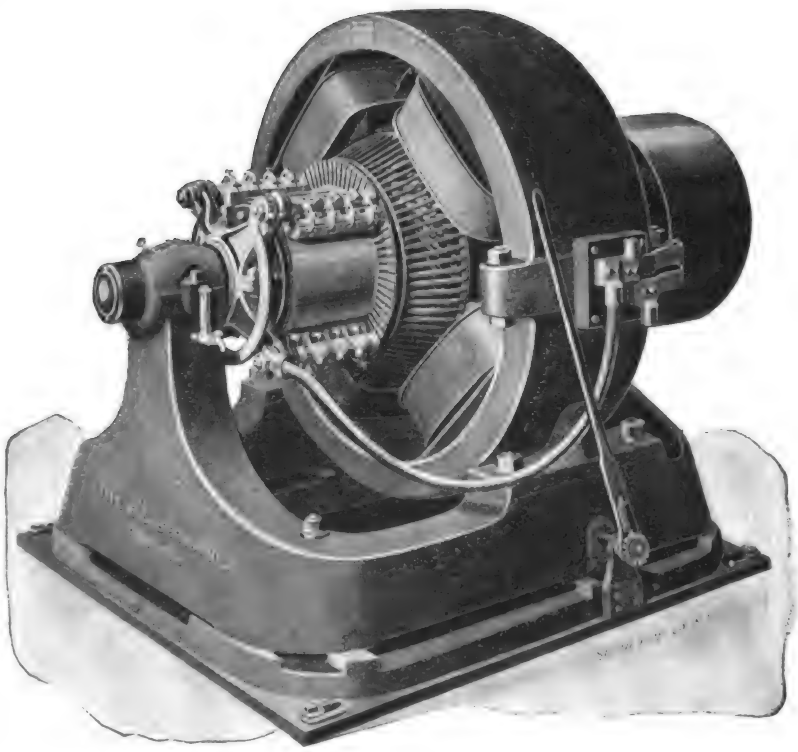
such a way as to give thorough insulation, and ventilation through longitudinal openings, which permit air to pass freely from one end of the armature to the other. The ventilation is further increased by air ducts perpendicular to the axis of the core. When in operation the armature ventilates practically on the principles of an exhaust fan, drawing in air at the ends and discharging it at the many openings in the periphery against the pole pieces, with the result that the machine always runs cool, thereby increasing the efficiency and enabling large overloads to be safely withstood. The armature coils are machine wound and thoroughly insulated before being placed in the slots. The winding is absolutely symmetrical, and so arranged that there are no crosses or conductors at a high difference of potential.

The commutator is thoroughly ventilated by air ducts and is from 10 to 30 per cent. larger than the average commutator on corresponding sizes of machines, thus giving plenty of brush contact and insuring cool running. By means of a special commutator clamp, the bars are set up under extreme pressure, thus insuring that high or low bars will not subsequently develop.

A new type of reaction brush-holder is used, by means of which the brushes adjust themselves to a bearing with minimum friction, and at the same time make perfect contact with the holder. The simplicity of the brush-holder is such that a brush can be easily replaced in five or ten seconds while the machine is in operation. The brush contact is based on about 25 amperes per square inch of carbon brush, this being from 20 to 40 per cent. more than is usually employed.

The bearings are the ball-and-socket type, self-oiling and self-aligning. By simply taking out two bolts, the entire bearing is exposed to view.

The machines are overcompounded to suit the requirements of any given case. They are claimed to be absolutely automatic in regulation, and work from no load to large overload without sparking at the brushes or undue heating. At normal load the elevation of temperature is much less than that usually allowed in specifications of engineers.



BERNARD MULTIPOLAR DYNAMO.

The new type of multipolar machine above described is made by the E. G. Bernard Company, Troy, N. Y.

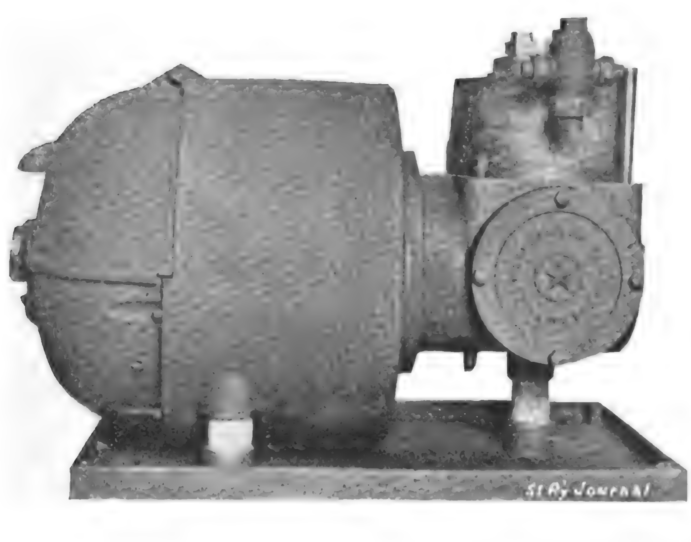
MODERN COMPRESSOR FOR AIR-BRAKING.

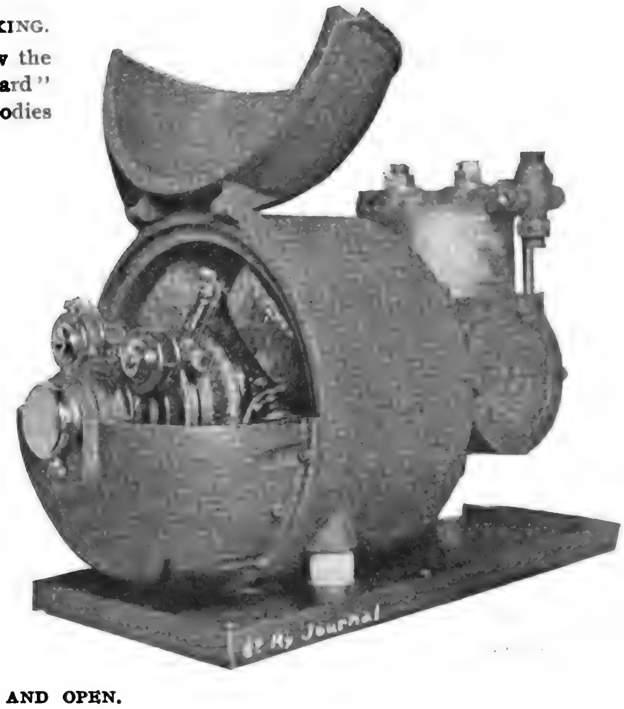
The accompanying illustrations show the new and improved type of the "Standard" compressor for air-braking, which embodies a number of improvements suggested in the practical working of this apparatus in the many installations that are now in operation in this country and abroad. The 1½-HP type is illustrated, and, as will be seen, is very compact, being but 26½ ins. long × 15 ins. wide × 18½ ins. high, weighing complete 400 lbs. The motor is the iron-clad, multipolar, slow-speed, series wound type, and is direct-connected to the air compressor, no gears being used. Both commutator and brushes are of generous proportions and the type of holder is such that an even tension is maintained, adjustments being required at only rare intervals. The armature is the slotted-drum type with windings of the Hochausen type. It should be stated that the Standard Company is the only concern which is authorized to use the Hochausen patents in air-compressor work. Damaged sections of the winding can be renewed, if injured, as in the case of car-motor armatures.

The compressor is of the single-acting type with double cylinders placed vertically, and trunk pistons connected directly with eccentrics in a crank case, the eccentrics being effectively lubricated by revolving in a closed chamber partly filled with oil.

The compressor is bolted to the end of the motor, and the shaft is a prolongation of the armature shaft, although not forming a part of it. It has a capacity of 11 cu. ft. of free air per minute when working under a gauge pressure of 60 lbs. per square inch.

The remarkably high efficiency of the compressor is largely due to the design of the valves, which involves a minimum loss arising from clearance; being made of steel that are light and practically indestructi-





STANDARD AIR-BRAKE COMPRESSOR, CLOSED AND OPEN.

ble. The air supply is drawn from a chamber, which although dust-proof, has so large an inlet surface that the work of drawing the air through the same is inappreciable.

This motor compressor has been in operation for a number of months, having been mounted on a number of cars with very satisfactory results. The operation is completely governed by an automatic current controller, which relieves the motor of responsibility of starting the motor when necessary to replenish the air supply, and cutting it out as soon as the needed supply has been obtained.

The Standard Air-Brake Company furnishes its own type of brake rigging for use with its system and is prepared to equip a car with everything in the braking line down to the brake shoes.

A NEW AUTOMATIC TELEPHONE SYSTEM.

In our February issue we published an announcement of a new automatic telephone system then being prepared for the market. This system has now been completed, and a successful exhibition was recently given at the offices in New York, the Smith-Vassar Telephone Company, of Lord's Court, being the owners. In a future issue the system will be described in detail.

The two principal features of the system are the selecting device whereby when a call is made a wire not in use is automatically selected and cut in; and the method of automatically cutting in a station with which conversation is to be held.

Instead of having for, say, 100 subscribers, 200 wires leading to a central station as in the present system, only as many wires are required as will probably be in use at the same time, which for the above number usually will not be over ten. Any one of the 100 subscribers on such a line can call up any other subscriber without the intervention of a central station, and without interfering with any other circuits in use; each pair of telephones when talking has an individual circuit, and during the time the telephones are off the hook, no one else can cut into the line or listen to the conversation carried on. In a city where there would be a large number of subscribers, each circuit, containing 100 telephones or more, would enter a central station, the operator there merely connecting one section with another, the subscriber automatically calling up the person with whom he wishes to converse.

The system is not based upon the step-by-step method heretofore used in automatic telephony, being much simpler in its details, entirely reliable in operation and with only the resistance of the apparatus of a single station in the circuit at any time, whether there are only a dozen or several hundred stations in the section.

It will be seen that the Smith-Vassar system is peculiarly applicable for small towns, and in that case a single section will be sufficient, central offices thus not being required. The policy of the company is not to enter the large towns and cities in opposition to the Bell Company, but rather to occupy the small towns and villages in which, owing to the high cost of construction and maintenance, the Bell Company has not been able to operate. The details of the system, it may be added, have been worked out by experts competent to deal with the problems presented, Mr. Smith having been a former superintendent of the Western Union, while Mr. Gilliland, who has charge of the factory, being one of the best known of the pioneers in telephony. A number of contracts have already been taken to equip small towns.

LARGE FOREIGN ORDERS FOR AMERICAN MACHINERY.

The British Thomson-Houston Company of London, through its representative, Mr. A. K. Baylor, has just closed an important electric railway contract with the companies operating the tramway systems of Dublin, Ireland, and Barcelona and Madrid, Spain. The contract for Dublin includes all steam, as well as the electric generating and motor equipment, and comprises six Allis horizontal engines of 500 HP each with Babcock & Wilcox boiler capacity necessary; six 500 KW, multipolar General Electric generators for direct connection to the engines, and complete switch-board and station equipment. The car equipment will consist of 150 complete motor and series parallel controller equipments, the motors to be mounted on Peckham trucks. This contract follows closely that made for the equipment of the Clontarf line of the Dublin tramway system, which will be opened within the next week or two. The apparatus for this was also supplied by the British Thomson-Houston Company. The contract signed for the Barcelona and Madrid roads cover five 400-KW, multipolar General Electric generators and three of 75 KW each, all to be directly connected to the engine shaft. While the three latter will be lighting generators, they will also be wound for 500 volts. This contract also includes full station equipment.

PERSONAL.

Mr. Seth C. Adams has resigned as secretary and treasurer of the Bossert Electric Construction Company, of Syracuse. Upon leaving, the employes of the company presented Mr. Adams with a handsome gold watch, chain and charm, as a remembrance of their pleasant relations.

Mr. Andrew King, former secretary and manager of the Edison-Allegan Light & Power Company, Allegan, Mich., has purchased the Mancelona Electric Light & Power Company's plant at Mancelona, Mich. The new firm's name will be The Mancelona Electric Company. Extensive repairs and extensions will be made at once.

Mr. C. C. Haskins, one of the best known of the electrical pioneers, has severed his connection with the municipal government of Chicago, after a service of 13½ years as city inspector of electric lights. Mr. Haskins has established himself as an electrical expert in Room 623, Western Union Building, Chicago. With his great experience in various branches of electricity his entry into the general field is a real acquisition.

Mr. E. J. Wessels, general manager of the Standard Air-Brake Company, returned by the Cunarder "Lucania" on Aug. 27, after three months' business trip abroad, during which he visited the street railway convention in Hamburg. While in Europe Mr. Wessels also appointed several agents for his company as follows: Messrs. Dick, Kerr & Company, Ltd., the well known tramway supply company, 110 Cannon Street, London, E. C., will be the sole agents of the Standard Air-Brake Company for the United Kingdom; Messrs E. H. Cadiot & Company, 12 Rue St. Georges, Paris, who have acquired the Standard Air-Brake Company's agency for France. It is expected that a good business will follow these appointments. The Bergische Stahl-Industrie of Berlin, which represents the Standard Air-Brake Company on the Continent, has inaugurated a very good business in air-brakes.

NEW BOOKS.

JOHNSTON'S ELECTRICAL AND STREET RAILWAY DIRECTORY FOR 1897, New York: The W. J. Johnston Company. 748 pages. Price, $5.

In the current volume of this biennial directory the growth of the independent telephone industry is illustrated by the considerable space taken by the lists of miscellaneous telephone exchanges, which include those already in existence or which have been recently incorporated. The other features remain apparently the same as in preceding volumes.

BLOCK-SIGNAL OPERATION: A PRACTICAL MANUAL. By Wm. L. Duer. New York: D. Van Nostrand Company. 270 pages, illustrated. Price, $1.50.

The aim of this book is to present the latest practice in block-signal operation in this country and Europe. All of the various systems in common use are described, with directions for their installation. One of the features of the book is the practical information for the operation of block-signaling systems, which is in the form of explicit instructions rather than general directions. One of the chapters of the book is devoted to a method of the autho- for "Single-Track Blocking."

TRADE PUBLICATIONS.

Steam Specialties. The most recent of the trade public tions of the A. A. Griffing Iron Comp ny, 66 Centre S reet, New York, are two circulars on Bundy steam specialties. Both of these relate to the Bundy low-water alarm, separator, feed-w ter heater and steam traps, one also containing some additional matter on other Bundy steam speci lti s.

Boiler Incrustation and Corrosion. Mr. Geo. W. Lord, 316 Union Street, Philadelphia, has published in pamphlet form a number of essays on boiler incrustation and corrosion, in which a vast amount of information is given concerning these subjects. Every one interested in steam generation will find this an instructive treatise.

Electric Supplies. Each edition of the illustrated catalogue of the Manhattan Electrical Supply Com-p ny, 32 Cortlandt Street, New York, grows in size, the latest (No. 9) containing 304 octavo pages, with over 1000 cuts. The art cles listed consist of house furnishin s, telephone, tel graph and electric light supplies, tools and novelties, representing many thousand items.

Arc Lamps and Incandescent-Lamp Hangers. The United Electrical Supply Company has issued two circulars, one of which describes a new type of incandescent-lamp suspension known as the "Two Balls" adjustable incandescent-lamp hanger, the other being devoted to the "W. J. C." alternating-current arc lamp, one of the features of which is a ball-bearing movement.

Incandescent Lamps. In an extremely neat little pamphlet, entitled "Film-Flam Tests versus the Test of Experience," the Warren Electric & Specialty Company, of Warren, O., pays its respects to the "Lamp Trust," and in so doing relates an anecdote concerning a personal controversy which was an enlivening feature of one of the days of the National Exhibition at New York last year.

Construction of the Incandescent Lamp. Perhaps the best written and illustrated description of the construction of the incandescent lamp yet given is contained in a handsome pamphlet issued by Machado & Roller, 203 Broadway, New York. All of the various operations are clearly and simply described, and illustrated by views taken in the lamp factory of the Allgemeine Elektricitäts-Gesellschaft, at Berlin.

Lubricators. The new and recently issued catalogue of the Detroit Lubricator Company, besides showing a very complete line of sight-feed lubricators, glass and brass oilers, oiling devices, globe valves, etc., contains some tables and data of general interest. A valuable feature of the pamphlet consists of the concise directions given for attaching and for the care of the various types of lubricators described and illustrated.

Electrical Novelties and Scientific Toys. The Carlisle & Finch Company, 828 West Sixth Street, Cincinnati, O.,in a recent catalogue describes and illustrates a line of electrical novelties and toys. Among these are a complete electric railway, a coal-mining locomotive and train and a hand power-dynamo. All of the apparatus are made from new and original designs and have a more mechanical appearance than the usual articles of this kind on the market.

Art in Advertising. The Western Electric Company has issued two excellent engravings, well printed on cardboard, and with the advertising so small in amount and so inconspicuous as to detract scarcely any from the artistic appearance. One of these is a fine half-tone view of Niagara Falls, and the other a similar reproduction of David's masterpiece in the Louvre, the former having the title of "A Great Source of Supply," and the latter "A Battle of Competition."

House, Line and Telephone Supplies. In a new catalogue having a striking cover, Stanley & Patterson, 32 Frankfort Street, New York, give an exhaustive list of electric bell, battery telegraph and telephone supplies, 287 closely printed pages being necessary for this purpose. In addition to this catalogue, the same firm issues one devoted to electric light and railway supplies, of which they are also manufacturers. In both catalogues all the various types of articles are illustrated.

Automatic Cut-off Steam Engines. Another addition has been made to the list of luxurious engine catalogues in that of the Ball & Wood Company, 120 Liberty Street, New York, the engravings, typography, paper and binding of which are of the most artistic character. The text is better written than in most trade publications, and taken in connection with the excellent accompanying illustrations, will enable the reader to form a clear idea of the principles of the modern high-grade automatic engine.

Electric Railway Specialties. The Cen ral Electric Company, of Chicago, is sendin out a neat and comprehensive sma l catalogue of electric railway quick-break snap fusible switches. These switches are made in various designs for controlling car-lighting circuits, and also in combinations enabling one switch to control two headlights as well as the car-lighting circuit. With the catalogue the same company is sending out circulars of its changeable electric headlights, which already h ve entered into large use.

Edison Specialties. The Edison Manufacturing Company, 110 Eas Twenty-third Street, New York, has issued a new catalogue of the var ous Edison specialties which it manufactures, the contents being considerably ful'er than o the edition which it supersedes. Among th article illustrated and described in full detail are Edison-Lalande batteries, Edison motors and fan outfits. Edison projecting kinteoscopes, Edison X-ray apparatus, Edison cautery transformers and Edison electro-medical apparatus. The descriptions are unusually clear and complete.

Wagner Bulletins. The August bulletins of the Wagner Electric Manufacturing Company, St. Louis, Mo., are four in number, devoted respectively to direct electrically-driven ventilating fans, alternating-current switch-board instruments, multipolar direct-current motors and generators, and self-starting, single-phase, alternating-current power motors. Each of these is a well-written and illustrated technical description of the subjects included. The same company has also recently issued a twenty-six-page catalogue of high-grade switches and switch-board material for street railways, central stations and isolated plants.

A Mammoth Catalogue. The new edition of the general catalogue of the Electric Appliance Company, Chicago, is a large octavo volume of no less than 567 pages, bound in a substantial and handsome cloth cover. The number of illustrations probably considerably exceeds 2000, and with generous margins and good typography on paper of book quality, the pages present an appearance more pleasing than is usually associated with catalogue publications. This substantial volume is principally devoted to electric light, power and railway supplies, the other subdivisions being telephone and telegraph supplies and electrical house goods.

BUSINESS NEWS.

The American Electrical Works, have had a post office established in their immediate vicinity, and their address will hereafter be Phillipsdale, R. I., instead of the former address, Providence, R. I.

The Star Dry Battery Company, 143 East Eighth Street, has removed its factory and offices to the above address, where increased factory room will facilitate the delivery of orders for its line of dry batteries.

Interior Conduit. The Interior Conduit & Insulation Company, 527 West Thirty-fourth Street, New York, says it is having the largest conduit business in the history of the concern. The bulk of the interior-conduit business of this country is done by the above company.

Reviving Business. The Diamond Electric Company, Peoria, Ill., finds the outlook for trade very encouraging. It is shipping goods now throughout this country from one end to the other, has very good trade in Canada, and some trade in Mexico, Japan, England and South America.

Standard Air-Brakes. The Standard Air-Brake Company has recently closed several important contracts for its various types of apparatus. Among these is one for six air-brakes for one of the British colonies, another a further contract for fifteen complete air-brake outfits, and several contracts from some of the continental cities.

The Standard Underground Cable Company has opened an office in Rooms 1225 to 1226, Betz Building, Philadelphia, with Mr. T. E. Hughes as manager. Mr. Hughes was formerly manager of the wire department of the company in New York, and will, from the Philadelphia office, hereafter give his entire attention to the trade in the South Atlantic States.

Incandescent Lamp Hanger. Mr. M. L. Vought, of LaCrosse, Wis., has recently placed upon the market an adjustable hanger for incandescent lamps which seems to be destined to fill a long-felt want in this direction. The hanger is sold at a very low price and is having a very large sale. The United States Electrical Supply Company, of 120 Liberty Street, is the Eastern sales agent.

Large Direct-Connected Engines. The Allen gheny County Light Company, Pittsburgh, Pa., has recently installed four very large Westinghouse engines of the vertical, compound-marine type, each driving Westinghouse two-phase 1500 KW generators. These are the largest steam-driven alternating current machines ever built, and the engines are the largest to which alternating-current machines have ever been direct-connected.

Life of High-Speed Engines. The J. S. Menken Company, Memphis, Tenn., in a letter to the Ball Engine Company, Erie, Pa., ordering a crank-pin box for a 60-HP engine, says that this is the first repair part ordered since the installation of the engine ten years ago. The Ball Company considers to substantiate its claim, which has been verified in other instances, that a well built high-speed engine has as long a life, with greater freedom from repairs, than a slow-speed engine.

Carbons. The American Carbon Company, Noblesville, Ind., reports its factory running on full time, and states that business has never been better than it is at the present. It has been compelled to increase its capacity nearly one-half during the past season, and even with this increase it is barely able to keep abreast of its orders. It states that it is much pleased with the outlook for an unusually heavy trade the coming season, and it is preparing to again increase its facilities to meet this trade.

The H. Channon Company has lately taken orders for its Ajax transmission rope for use with an elevator now being erected at Peoria, Ill; a new mill of the Texas Star Flour Mill Company, going up at Galveston, Tex.; an elevator for the Louisville & Nashville El vator Company, at Pensacola, Fla.; a new elevator for Kingston Elevator & Tran it Company, at Kingston, Ont., and a large drive for the Louisvil e & Nashville Railroad Company's elevator, which is probably the largest in the country.

The B. & O. Tunnel. Mr. E. Tremlett Carter, the well known English electrical engineer, and editor of the London *Electrician*, recently inspected the electrical equipment of the B. & O. at Baltimore, the London Underground Railway having adopted the style of motors that the B. & O. uses in the Baltimore tunnel. At the conclusion of his inspection, Mr. Carter said that it was the most complete and economically handled plant he had ever seen, and that he had never been in a tunnel that was so absolutely free from smoke.

Desk Lamps. McLeod, Ward & Company, New York, report a great improvement in business, with prospects for fall trade excellent, especially in the Kinsman desk-light specialty. This lamp has been on the market for the past four years, and still retains its high reputation as a desk lamp, as is evidenced by the continued increase of sales each succeeding year and the flattering testimonials received from users. It is claimed that the Kinsman is the only fixture made that will properly light the desk and at the same time protect the eyes.

Brazing Graphite.—Not a littl of the expense in brazing is due to the cost of removing th brass which has stuck to the metal where it is not wanted. The removal of this brass is usually attained only by patience and d ligent filing. Now comes to the aid of the brazier that unique mineral, graphite, which is not effected by acids, alkalies, heat or cold. Braziers who have made use f Dixon's pure flour of graphite pronounce it worth its weight in gold. A sample will be sent without charge by the Joseph Dixon Crucible Company, Jersey City, N. J.

The Puritan Electric Company, New York, maker of the Puritan al ernating-current, enclosed-arc lamp, owing to its increasing Wes ern trade has appointed Mr. George Walker Conover, as Western representative. His office is in the Monadnock Block, Chicago, Ill Mr. Stewart W. Wise, presid nt and general manager of he company, states that through its Boston agency it has just received an order from the Boston Ele tric Light Company for twenty-five of its new type alternating-current enclosed-arc lamps, which will be placed in the new East Armory, Boston.

Independent Telephone Exchanges. After a hard fight with the loca Bell Telephone Company, Mr. W. J. Kurtz, president and manager of the National Telephone Company, Indianapolis, together with Mr. P. A. McDonald, has arranged to establish a Anderson, Ind., an independent telephone company. Mr. Kurtz is also at the head of a co-operative company at Indianapolis, which will also establish an exchange in that city. The National Company is installing 500 telephones in St. Louis, 225 in Muncie, Ind., 100 additional in St. Joseph, Mo., making 600 in all, and 100 have been installed at West Point, Ga., and are now in use.

Gas Engines. The Wolverine Motor Works, Grand Rapids, Mich., are enjoying a splendid fall trade, and they feel especially well pleased with their foreign trade, which has never been better than at present. Recent sales reported are: One 10-HP and one 2-HP gas engine for Yucatan; one 2-HP engine for Tuxpan, Mex.; for the United States of Colombia, four engines, one of 30-HP marine, three of 8-HP marine, one for a 33-ft. launch and one 10-HP plantation locomotive. Besides these, they have made several large sales in British India, Egypt and Australia, not to mention the large demand for this engine in Canada and the United States.

The C. & C. Electric Company, of New York, reports a steadily increasing demand for its new types of multipolar, slow-speed dynamos and enclosed ironclad motors, as well as a steady demand for its well known bipolar-type machines. These orders are not only coming from all over the United States but from a number of the fo eign countries as well. The C. & C. Company is now represented in Central America, Mexico and Japan, and will send representatives this month to St. Petersburg and to London. The works at Garwood, N. J., present a very busy sight just now, as they are operating with a very considerably increased force and every night in the week.

The Chandler & Taylor Company, of Indianapolis, has just issued a new catalogue describing the various types of engines which it manufactures. This catalogue is one of the most artistic yet placed before the trade, an it should be in the hands of every consul ing and constructing engineer. The Chandler & Taylor Company reports increased activity in trade and to the inquiri s of a representative of the AMERICAN ELECTRICIAN stated, "Yes, business is much betterand we have to report, as a little out of the ordinary, orders for

two engines for Alaska, so you see although we are not going ourselves, we will have a representative in the Klondyke district."

Walter C. McKinlock, 1108 Dearborn Building, Chicago, who recently started in the general electric supply business for himself, reports trade in his line increasing daily, having received some nice large orders for rubber-covered wire and weather-proof line wire. Mr. McKinlock represents one of the largest wire factories in the East. Mr. McKinlock is handling the Merritt Electric Company's products. This firm refills any lamp made in a manner that makes it impossible to distinguish it from a new lamp, and as a new and superior filament and new vacuum are the only essential things, there is no good reason why every lamp user should not renew his lamp.

The Boiler Expurgator Company, 115 Dearborn Street, Chicago, states that the sale of Holm's Tesoline is rapidly increasing and especially in Chicago and the West, as it now has as patrons nearly all of the principal isolated plants and a large number of electric light stations in that territory. This commutator compound seems to be giving universal satisfaction wherever used. Sample sticks are sent free on application. Every engineer should have a copy of this company's "Rules" for the engine room. We quote Rule No. 6, as follows: "Be sure and tell the engineer if his engine is pounding or running all right, as he would not know it; he will stop it and make repairs while you wait."

The Ideal Electric Corporation, New York City, reports much activity in its shops, and the indications for fall business are very good. This concern has booked several good orders for future delivery in addition to those in course of completion. The Ideal Electric Corporation is supplying all the panel and distributing for the new Columbia College, and is now busy installing the same. It also has contracted to supply and install a main switchboard for Standard Oil Company's building, New York City, and main and stage switch-boards for Metropolis Theatre, Harlem. The lamp department is running full force, many orders having recently been booked for the A. C. long-burning lamps.

The American Rheostat Company, of Milwaukee, has recently increased its capital stock $25,000. Starting in a small way, the American Rheostat Company has steadily grown, until to-day it enjoys the patronage of a host of customers throughout the entire world. This company's trade with supply houses is especially large, and is especially satisfactory to that branch of the trade on account of the prompt manner in which orders are filled. The company has been obliged to add a number of skilled workmen to its force from time to time, and reports that it has recently put on quite a number of extra men. Its new "Perfection" rheostat is giving great satisfaction to the trade and is universally commended.

Made for Germany. The Vilter Manufacturing Company, of Milwaukee, is enjoying the benefit of a number of fine orders recently received for its machinery. This company recently had the pleasure of furnishing a large plant for a brewery in Dortmund, Westphalia, Germany. With the filling of this order Mr. William O. Vilter enjoyed squaring an old grievance of American manufacturers. As has been noted in the past, a great many articles in this country bear the trade mark of "Made in Germany." The large engine furnished by the Vilter Company to this plant in Westphalia had emblazoned on it in a very prominent way the statement, "Made for Germany." The Vilter Company makes a specialty of apparatus for breweries, and one of its recent installations was at the big Blatz plant in Milwaukee.

The W. H. Elliott Electric Company, of Cleveland, O., reports that its repair business has been unusually good of late, it being necessary to run 18 hours per day in order to get out the work on hand. The company makes a specialty of electric railway work, and at present has in hand a number of large railway generators that will keep it busy for the next two months. In its work the company uses what is called the ventilated head system of winding which, it is claimed, permits the conveying of a larger load without an increase in temperature. The company has had some 15 years' practical experience in repair work and it allows nothing to go out of its shops without it being thoroughly tested. It has on file testimonials from many of the largest street railway companies in the country.

The Commercial Electric Company, of Indianapolis, Ind., states that it has been compelled to increase its factory force over 50 per cent. A representative of the AMERICAN ELECTRICIAN recently had the pleasure of inspecting this company's factory and he found that the statement as to its increased trade unnecessary, as every man and machine in the works was running full blast. Mr. Southworth, the engineer for this company, stated that it would be compelled to put on a night force shortly to enable it to keep up with its orders. A few of the recent sales made by this company are as follows: 40-KW, 250-volt lighting plant for Knox, Ind.; 12.5-KW machine with engine to Highland Brewing Company, Highland, Ill.; 25-KW machine to W. W. Mooney, Columbus, Ind.; 15-KW, direct-connected machine to Lowell, Ind.; 25-KW, direct-connected machine to the Star Store, Indianapolis, and many others.

The Electric Appliance Company is well pleased with its experiment of carrying in stock in Chicago a line of porcelain in all styles and sizes of knobs and tubes, that would enable it to fill any order. The advantage of having this stock in Chicago instead of having to go to the factories for this material seems to be appreciated by the trade, and the Electric Appliance Company is reaping very satisfactory results. It is the Chicago depot for one of the largest porcelain works in the country, and is carrying a much larger and better assortment of stock of porcelain than has ever been carried in Chicago before, and a customer's requirements must be very severe indeed, who cannot satisfy his wants directly from this stock. Mr. W. R. Pinchard, who is well and favorably known to the electrical fraternity, has recently accepted a position as city salesman for the Electric Appliance Company.

The Emerson Electric Manufacturing Company, 714-716-718 St. Charles Street, St. Louis, Mo., reports the past season a very successful one as regards the fan-motor trade. It states that notwithstanding the dull times, its sales have steadily increased and it was enabled to add many new customers to its list. For over four months this firm was compelled to run its factory twenty hours per day to enable orders to be filled in the prompt manner which has always been a characteristic of this company. The installation of a new switch-board for the Olympic Theatre of St. Louis has just been finished; also a new board for the St. Louis Exposition Building, which will carry over 10,000 lights. The indications for a heavy fall trade in its several specialties are very bright indeed, and it states that present orders on hand will keep it busy for some weeks unless it increases its working force, which it contemplates doing at an early date.

The Miller-Knoblock Company, South Bend, Ind., whose electric street sprinkling cars are well known, is adding to its already large business, an electrical department, which will be under the direct supervision of Mr. A. W. Morrell, an experienced electrical engineer and constructor, who has had years of experience in street-railway motor work. It is the intention of the company to manufacture and carry in stock ready to ship at a moment's notice, Morrell's improved assembled motor commutators for street railway motors. The fact that street railway men can procure assembled commutators for any and all standard street railway motors, will be appreciated. It will also carry in stock, armature coils for all the standard motors. A complete equipment for the rewinding of armatures has been put in. Mr. Morrell, who has charge of the electrical department, has had long experience in electric street railway work and is well known at St. Louis, Minneapolis, Indianapolis and Cleveland, where he has had charge at different times of important works.

Commutator Compound. In answer to an inquiry from a representative of this journal recently, Mr. Isaacs, of K. McLennan & Company, stated that while no doubt the conditions in the business world had materially increased and while the sales of Gale's commutator compound have increased, he did not believe that such increase in the sales of their compound could fairly be attributed to the times. Gale's commutator compound has become a staple article adopted and in regular use by nearly every power plant and central station in the United States and Canada and a vast number of isolated plants. In the fall season, or beginning from Sept. 1, a very much larger quantity of compound is used than in the summer and, in his belief, this is the real cause of the increased sales; doubtless, continued Mr. Isaacs, the recent reduction in price of Gale's commutator compound, has worked some increase, as some of the smaller plants may have felt that the former prices was too high. Mr. Isaacs added that if the AMERICAN ELECTRICIAN can find a single plant that has not yet tried Gale's compound, he will be glad to furnish a sample stick free, upon application to their office, Marquette Building, Chicago.

The Electrical Exposition for 1898. Ever since the Electrical Show held in New York City during May, 1896, there has been a feeling in the trade that it should not be the last. Its splendid success in the way of bringing trade to exhibitors has led to a very general demand that it be repeated. A company has been formed with $20,000 capital, and a live, up-to-date board of directors to conduct such an exhibition in 1898. Articles of incorporation were filed in Albany last month, and these gentlemen were named as officers and directors: Cyrus O. Baker, Jr., president; Ferd. W. Roebling, vice-president; George F. Porter, secretary and treasurer. These officers, with Leonard F. Requa, Chas. A. Lieb, J. W. Godfrey and H. H. Harrison, constitute the board of directors. Executive committee: C. O. Baker, Jr., Leonard F. Requa and H. H. Harrison. Mr. Marcus Nathan has been selected as general manager. This practically insures a first class exhibition. The new electrical inventions and improvements developed since the last show will be an important factor. The interest and co-operation of many manufacturers already assured will count for much towards making this a more complete demonstration of all the applications of electricity and its branches than was possible in the first exhibition in 1896.

Ideal Engines. The Ideal Engine Company has recently adopted a new combined centrifugal and inertia governor, and recent tests of engines equipped with it have shown remarkable results. One engine direct-connected to a 25-KW generator and installed in the Wabash Building at St. Louis, ran so steadily that a number of experts who were present at the test failed to detect any indication of fluctuation in the incandescent lamps when two electric passenger elevators ran from the dynamo were both stopped and started at once. Indicator cards taken from the engine showed variations of cut-off from less than one inch to half stroke, and it was found that within one-fourth of a second the governor would travel over its full range, the engine running at 200 r. p. m. The engine in the Wabash Building is believed to be the only direct-connected engine running both elevators and incandescent lights without affecting the latter when the elevators are started or stopped. The fluctuations of the speed were indicated by a sensitive tachometer which, when the elevators were stopped and started, would merely give a rapid wink, moving only one-fourth revolution and jumping back in less than one-half second, thus giving a variation of but one-half of one per cent. and extending over merely this small period of time.

Independent Telephone Movement in the East. The Citizens' Telephone Company of New York and New Jersey filed articles of incorporation Sept. 1, capital stock $1,000,000, for the purpose of building and operating a complete telephone system for the states of New York and New Jersey. While the company will make a specialty of toll-line work, its charter permits it to assist local capital in the establishment of exchanges and for the full equipment of exchanges where local capital is not accessible. Steps have already been taken for a trunk line to Buffalo via Binghamton, and another line will be built to Albany and thence west to Buffalo. From Buffalo, the Michigan state line people will build to Chicago. Contracts for toll-line connections have already been made with several of the most prominent independent exchanges in the two states mentioned, and preliminary negotiations are in progress looking to the consolidation and extension of existing toll lines. It is the first practical step taken in the East toward a complete bi-state system, and the promoters are receiving the strongest encouragement from operating exchanges and municipalities seeking competition in telephone service. The office of the Citizens' Company is in the New York Life Building, Mr. D. A. Reynolds, secretary, well known in connection with the Western independent telephone movement, being in charge.

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ELECTRICALLY DRIVEN PRINTING AND BINDING MACHINERY.

BY A. N. RATHBUN.

DRIVING machine tools by electric power is now accepted as the coming practice, its advantages having been effectively demonstrated in numerous large plants, and the problem of the application of electric power to printing, folding and binding machinery is finding a similarly satisfactory solution. Prominent among the large printing establishments electrically equipped is that of the S. S. McClure Company, publishers of *McClure's Magazine*, which was probably one of the first to adopt individually motor-driven presses to the exclusion of all others. While considerable advances have been made in electrical printing equipment since this plant was installed, it is yet one of much interest on account of the completeness of all of its electrical details.

The plant consists of eleven ordinary cylinder presses, two automatic cylinder presses, two rotary presses, four cutting and folding machines, one hydraulic press for pressing gathered sheets, several binding machines, a covering machine and numerous trimmers. Each of these machines is driven by its own motor. Fig. 1 is a general view of the press room and gives an idea of its extent.

The cylinder press does not need a detailed description, as it is often seen in a printing establishment of any size. It requires a 4- to 5-HP motor, according to the size, and the motors used take from 16 to 25 amperes at 230 volts. With this power a press can turn out 1200 impressions per hour. The motor, as will be seen in Fig. 3, is geared to the main shaft of the press. A special controller is provided by which the speed of the motor may be varied. This is important, because half-tone work on coated paper requires much slower press work than ordinary type on calendered paper, and the electric motor with its easily controlled speed enables the press to turn out either kind of printing at the highest possible rapidity. The automatic cylinder press requires a motor of about the same capacity, 4 to 5 HP, and can turn out impressions up to 1200 per hour, according to the nature of the work to be done. They differ from the ordinary cylinder press in having a self-feeding attachment. Paper is served to the press in a great pile. Sheet by sheet is pushed off of the pile by fingers which are ingeniously arranged, so that not more than one sheet will be fed to the press at a time. Fig. 2 shows this self-feeding press, while Fig. 4 shows in detail the method of connecting the motor thereto, which is typical of the method used on all of the presses in this establishment, excepting the rotaries.

The rotary presses used in this establishment are of two kinds, and both of them are marvelously automatic. They take their paper directly from the roll, print both sides of it, and cut it into sheets; that is to say, one of the presses does this, the one shown in Fig. 5. The other press does even more, as it cuts its product into four times as many sheets, folds them once and cuts them again four times, thus turning out complete signatures ready for binding. This press is shown in Fig. 6. Both of these rotaries require a 15-HP motor to drive them. The motor is installed in a specially provided space under the press itself. The rotary presses are capable of turning out 2000 sheets per hour, printed on both sides. The first of the presses described, which prints both sides without folding, has a small accessory motor of ½ HP to raise and lower the platform which receives the sheets.

These rotary presses afford particularly good examples of the superiority of electrical power for operating such machinery. At numerous points on the press are provided switches, any one of which will stop the motor. If the paper catches and fouls the press, the latter must be stopped at once, and failure to do this means destruction to many copies. Any one of the three operators has a switch right at hand and at the slightest sign of trouble the press can be stopped in an instant.

This figures a great saving in paper—how much is not realized unless one has to pay the bills of such waste from a printing press driven in ordinary manner. Such accidents are liable to happen in the best of presses, for the reason that the paper that is used is often highly charged with electricity, which

FIG. 1.—GENERAL VIEW OF PRESS ROOM.

causes the sheets to adhere and interferes seriously with their manipulation. In both of these rotary presses the electrical charge is reduced to a minimum by a jet of steam which blows over the paper before it enters the press.

The completed sheets that are turned out of most of the presses require to be folded, and for this purpose a folding machine such as is shown in Fig. 7 is employed. This machine requires from ½ to 1 HP. The sheets are fed to it from a large pile from the rear by a finger system very similar to that employed on the automatic cylinder presses. These fingers are assisted by jets of air, which blow in between the sheets, dispelling the electrical charge that may have accumulated upon them and preventing the sheets from sticking together. The air is supplied by a little positive-action blower driven by the same motor that operates the folding machine. The sheets are folded twice on one dimension, four times on the other, and then cut into four pieces,

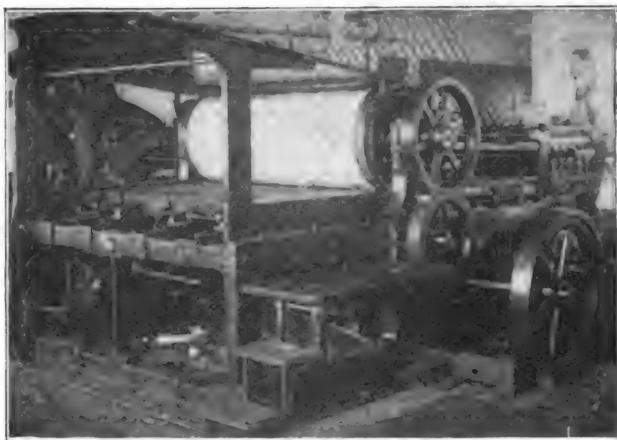
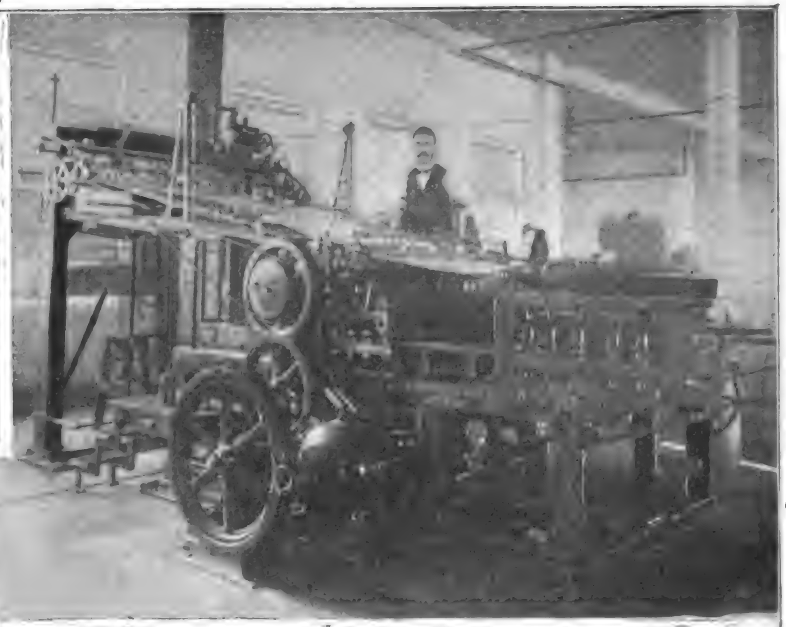
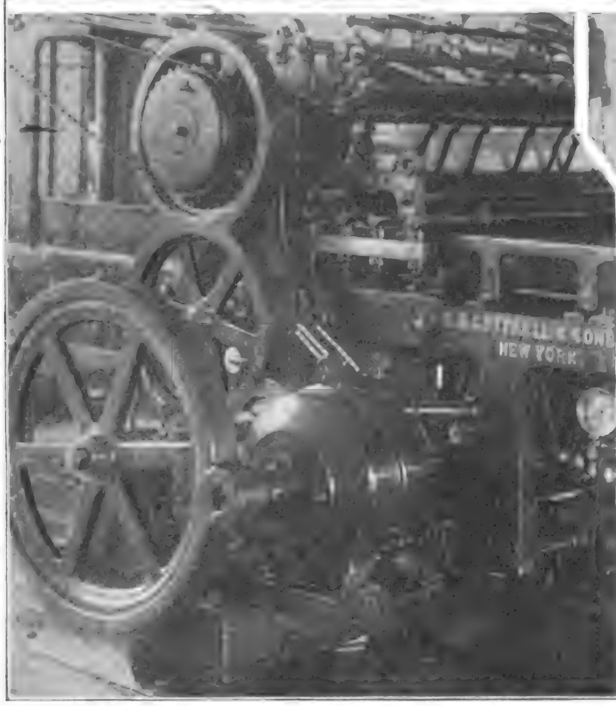
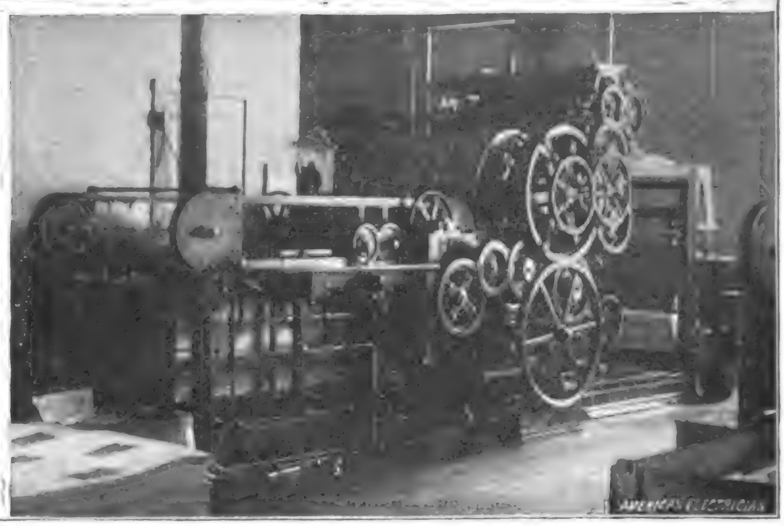
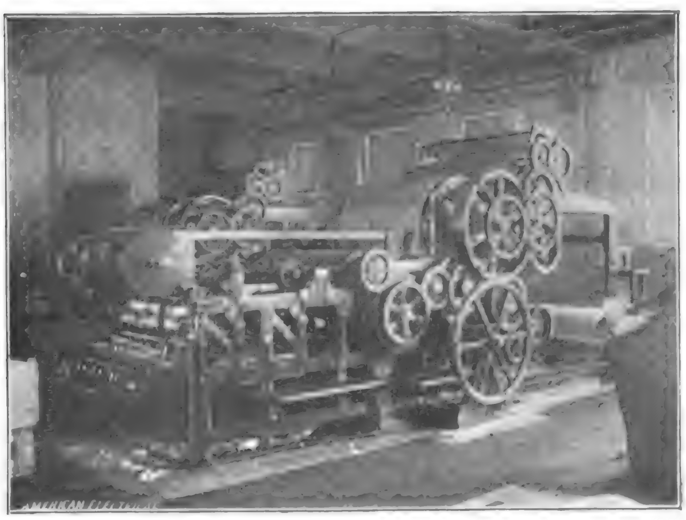







FIG. 2.—MOTOR-DRIVEN CYLINDER PRESS.
FIG. 3.—AUTOMATIC MOTOR-DRIVEN CYLINDER PRESS.
FIG. 4.—METHOD OF GEARING MOTOR TO PRESS.
FIG. 5.—ROTARY PERFECTING PRESS, MOTOR DRIVEN.
FIG. 6.—FOLDING ROTARY PRESS.
FIG. 7.—FOLDING MACHINE.

producing at every cycle of events four signatures. There are four of these machines at the printing establishment of the S. S. McClure Company, and they will each fold from 2000 to 3000 signatures per hour.

The folded copies are stacked together in the proper order and compressed in a hydraulic press driven by a 5-HP motor. The copies are placed in the press, and the latter is set up until the motor belt slips. The magazines are then taken out and put into a stapling machine, where the signatures are permanently secured together by two staples.

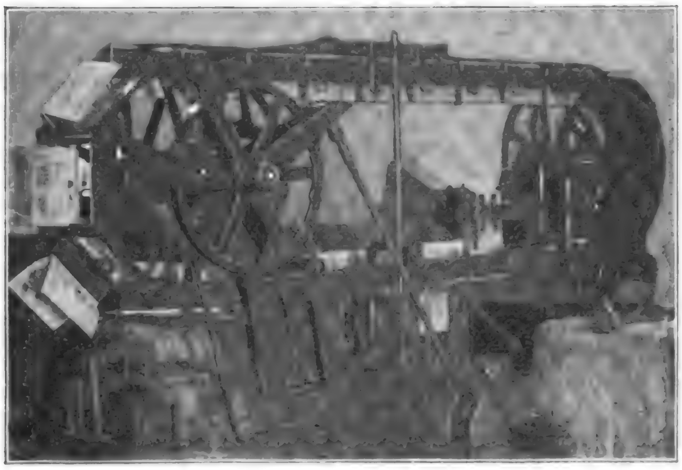


FIG. 8.—COVERING MACHINE.

A ½-HP motor is sufficient to drive from four to six stapling machines. The magazines are then ready for the covers, and these are put on by an automatic covering machine, which requires a 3-HP motor to drive it. The copies are stacked in a chute and are dropped one by one into a spring vise, which grasps them firmly and puts them through the following series of operations: First, the back of a copy is drawn across a wheel which is revolving in a heavy glue; second, a pile of covers are pressed against the glued back, and one of them adheres thereto; third, a set of jaws seizes the back of the magazine and firmly presses the cover on; the vise then travels four or five spaces while the glue dries a little more firmly; then the cover is pressed on again three times as the vise passes under three pressure fingers for this purpose; finally, the vise passes over a drop, when it is automatically opened and the covered copy is pressed on a pile on top of its predecessor, ready for trimming. There is a chain of these vises, which moves over a system of pulleys made purposely for it. The system moves with an intermittent motion, allowing each vise to pause for the proper interval over the various portions of the machine which glues the magazine, sticks on the cover and presses it into place. The trimming of the magazine is accomplished by electrically-driven paper cutters, but as there are no special electrical features concerning them, they have not been illustrated.

The circulation of *McClure's Magazine* is 300,000, and yet this extensive establishment requires three weeks to turn out the edition. This gives an idea of the magnitude of the work to be done.

The motor used here is of the Lundell type and particularly well adapted for the service required. It is completely iron-clad, and a single field coil excites all of its several magnetic circuits.

By the device of increasing the number of poles and retaining a series winding, the speed of the motor has been reduced so that the gears may be dispensed with and the motor directly connected on to the main shaft of the press. This is a marked improvement over geared connections in every way. The power necessary is reduced, the noise of the gears is eliminated and the life of the motor is prolonged. Fig. 9 shows a press so connected that it would be hard to specify anything simpler and more satisfactory. The iron-clad motor is practically damage-proof, and its flat shape enables it to be placed outside the press without inconvenience, in which position it is readily accessible.

The wiring about a printing press is necessarily of a substantial nature, and iron-armored conduit is a very satisfactory article for this purpose. Indeed, it may be safely said that some system of that nature is absolutely necessary. Oil, dirt and danger of mechanical damage are present in the proximity of a printing press to such an extent that a less protected construction could not endure.

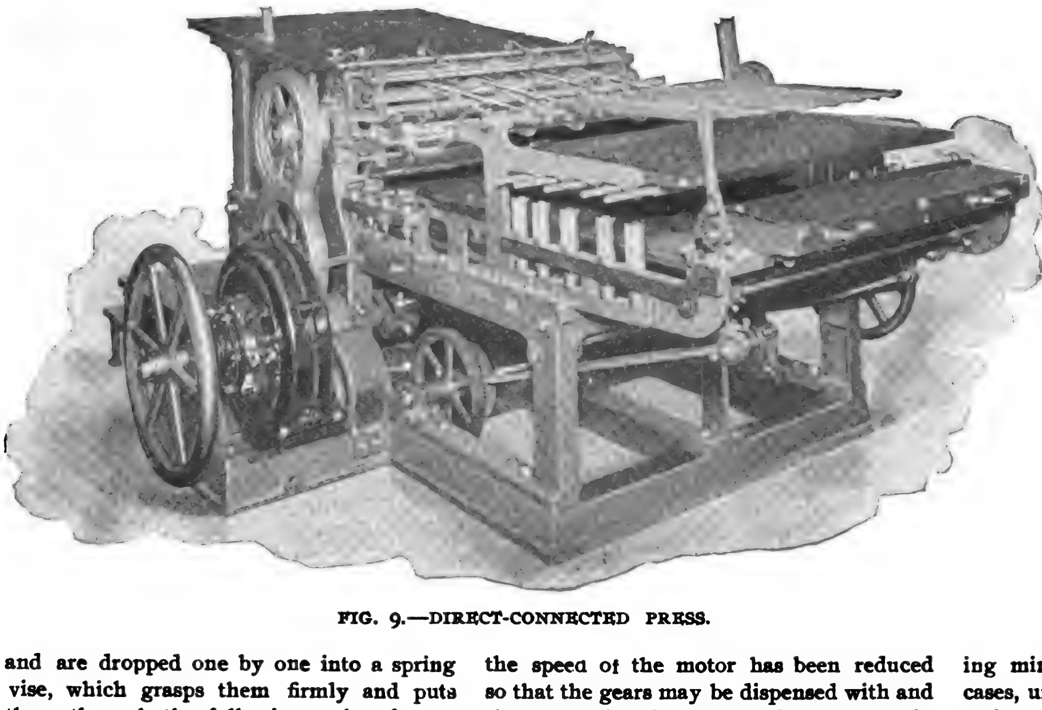


FIG. 9.—DIRECT-CONNECTED PRESS.

INSULATOR AND CABLE TESTING, WITH SUGGESTIONS FOR NEW APPARATUS.

BY N. MONROE HOPKINS, A. I. E. E.

The testing of insulation may be conveniently divided into two branches or systems; the break-down or puncture test and the actual measurement of electrical resistance in ohms.

In the testing of porcelain and glass insulators designed for long-distance power transmission, certain classes of railway work and all lines for high electrical tension, the break-down test prevails, and in many instances is preferable to careful galvanometer measurements in the testing of insulation on wires and cables. The puncture test may again be divided into the dry and the wet test, the latter being far more severe for very obvious reasons.

The difference of electrical potential brought to bear on insulators and cables varies, of course, with the thickness of the walls, in the case of porcelain insulators, and with the thickness and composition of the covering on wires and cables. In testing porcelain insulators a voltage of 40,000 for a period of forty minutes would be a good test for insulators whose walls are at least 1 in. in thickness. For insulators with walls ½ in. thick, 30,000 volts for forty minutes would be a good and severe test.

When an insulator remains intact when subjected to a test of approximately this severity, it is usually pronounced perfect. This, however, should not be the case, for many insulators undergo this tension without cracking or breaking in any way, for the presence of a conducting mineral in the clay carries the current. These faulty insulators can at once be detected, as they become intensely heated in the neighborhood of the conducting mineral. They are, however, inmany cases, unjustly shipped with those that remain unaltered and cold, partially because they are not discovered, as they make no buzzing sound like the cracked ones, and partially because of the ignorance of the man in charge.

Again, a test of this character is not a fair one if several heated insulators are allowed to remain on the testing table with the others, for the conducting minerals in the

faulty ones only furnish electrical paths, or equalizing paths, across the high-voltage feed wires, with a result at once apparent.

The method of holding the insulators on the testing racks or tables is frequently also

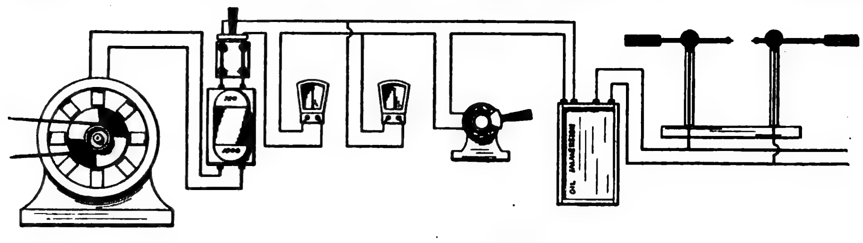


FIG. 1.—DIAGRAM OF CONNECTIONS.

very faulty, as the electrical stress is frequently not applied where it will eventually come in practice when the insulators are called upon to support a high-tension line wire. High-potential, long-distance lines are developing quite rapidly, and leaks due to faulty insulators only mean the combustion of additional pounds of coal in the generating station, or a smaller output in the case of turbine units.

It is the wish of the writer to describe here some methods of insulator and cable testing which may be made as severe as may be necessary for all purposes, bringing the electrical stress right when it will come in practice. The writer also offers one or two suggestions which may prove of assistance to those who wish to experiment along lines of this character. This puncture testing requires great carefulness, as carelessness in handling a

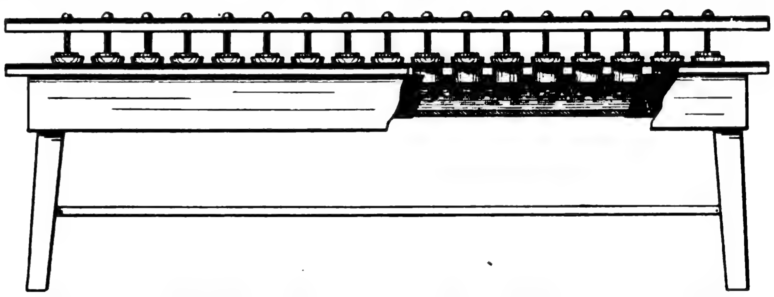


FIG. 3.—IMMERSION FORM OF RACK FOR TESTING INSULATORS.

testing laboratory of this class would obviously result in fatal accidents.

Fig. 1, represents an alternator designed for 1000 volts, with diagram of connections. A "step-down" transformer is introduced, lowering the voltage to 100, giving a convenient line current for the measuring instruments. A controlling or "choking" coil is included next, whereby the voltage is slowly raised. An oil immersion transformer, or group of ordinary transformers designed to give the proper raise in voltage, is located in a safe and convenient place. The approximate voltage may be ascertained by taking readings from the instruments and estimating for the transformers, or by a table of spark-gaps.

Tables on spark-gaps are only very approximate, as the gap will vary with dry and damp weather. For a 30,000-volt test, the spark-gap should be set at 1½ ins. on an average day. Any appreciable rise in voltage will cause a discharge to take place across the gap between the sharp points or needles. By referring to spark-gap tables and comparing the readings of the instruments, taking correct consideration of the transformer, the voltage may be learned quite near enough for testing purposes, as with a set spark-gap once established all insulation subjected on days of equal humidity will receive the same breaking-down strain.

Fig. 2 shows a side view of a testing table with an iron top, with punchings to receive the insulators. A table wide enough for two or three rows is the usual practice, having a capacity for about forty insulators at a time.

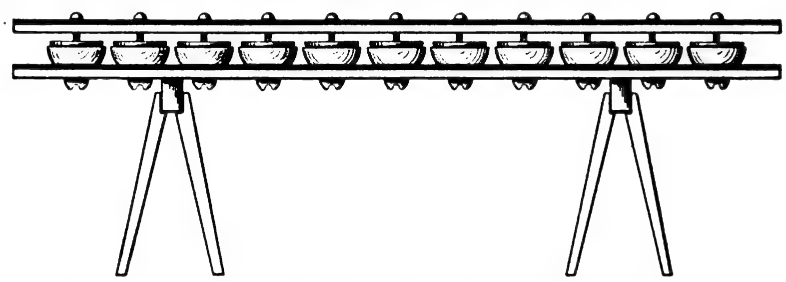


FIG. 2.—ORDINARY FORM OF RACK FOR TESTING INSULATORS.

It will be readily seen that the electrical stress is all between the end of the iron pin which rests in the insulator, and a circle described about the outside, where the circular punching supports it. This is a common type of testing table now in use. As of possible interest to those who have not wit-

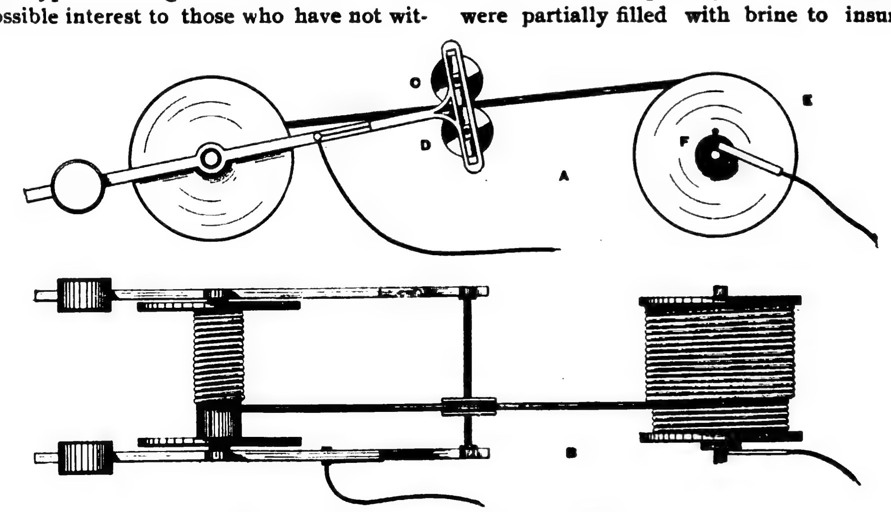


FIG. 4.—CABLE TESTING—DRY METHOD.

nessed a practical test of this character, the behavior and condition of things during and after the run of thirty minutes will be described.

Let us consider this common type of table with the circular holes with forty insulators. The generator is started and the switch over the transformer closed, with the controlling coil thrown well over for the maximum "choking" effect. The instant the switch is thrown, a deep and loud humming noise is produced, changing in tone from a "singing" to a harsh buzzing, until an insulator cracks or punctures, when a shrill piercing sound is emitted, accompanied, by the liberation of ozone, which is more or less noticeable from the time the switch is first thrown. The poorly baked and faulty insulators go to pieces within five minutes and those of a little better glaze, or more perfect baking do not follow much before fifteen or twenty minutes. During the remaining ten minutes of a test of about one-half hour very few, as a rule, puncture.

Of course, when an insulator punctures its presence and location on the table is detected by its loud singing and the presence of a glow when it is in contact with the table top. The "choking" coil is thrown over and the switch opened and the punctured insulator and its iron pin are removed. The fatality among carefully made insulators is from 8 to 10 per cent. when subjected to 30,000 volts, when their walls are not more than ½ in. thick. Of course, these figures will vary somewhat with different clays and bakings, etc.

Fig. 3 represents an immersion table designed by the writer with which he has as yet made no experiments. With a strong solution of salt in the tank, it is readily seen how "searching" and severe a test on this table would be, especially if the insulators were partially filled with brine to insure electrical stress on every point of the inside wall.

Fig. 4 represents a contrivance, which as yet is only the writers' suggestion, for test-

ing the insulation on wires and cables as they are wound from one drum to another, *A* being a side wire and *B* a plan. The grooved wheels *C*, *D*, with little sliding blocks for bearings, are kept against the cable by small springs, not shown in the drawing. The weighted arms are of wood

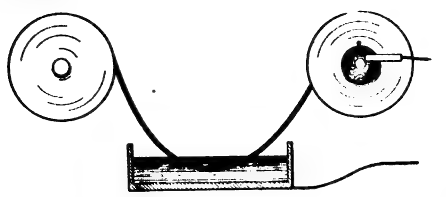


FIG. 5.—CABLE TESTING—WET METHOD.

until near the end, where the metal slotted guide joins. The conductors of the cable are brought out through a hole in the spool, *E*, and connected with the plate, *F*, which is in contact with the sliding brush. The entire electrical stress or puncturing tendency is brought to bear directly on the insulation between the conductors and the grooved wheels, which nearly encircle, or embrace, the cable. The pulleys are loose on their axles so they may follow the cable as it winds or unwinds from the drums. By virtue of the pivoted arms the wheels are able to keep to the cable as it rises or lowers because of the different layers on a drum. As this illustration is intended to be entirely of a suggestive character it is, of course, subject to modification to meet the requirements of specific cases.

Fig. 5 shows a much simpler method of applying the stress to the insulation. As it would be undesirable to wind the cable on the drum after passing through brine without wiping and drying, some means to effect this should be devised without endangering the attendant.

A UNIVERSAL ALTERNATOR FOR LABORATORY PURPOSES,

BY PROF. HENRY S. CARHART.

The design of the machine illustrated in the accompanying engravings was adopted for the following reasons:

1. Simplicity of construction by students in the engineering shops, without special tools or dies; 2. Its similarity to a bi-polar dynamo so as to illustrate one, two or three-phase-current generation, but without a low limit to the frequency; 3. To illustrate practically the effect of combining E. M. Fs. differing in phase, in a variety of ways.

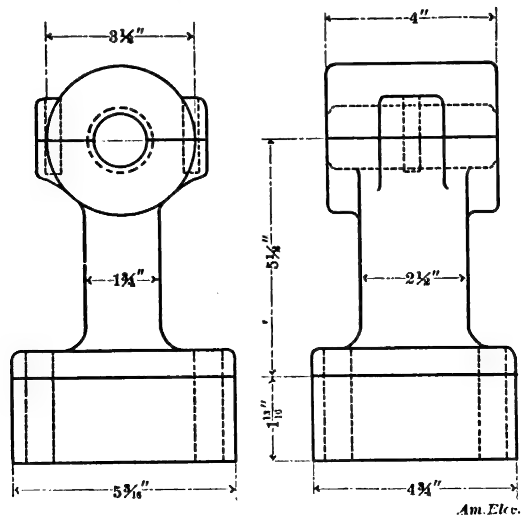


FIG. 1.—PEDESTALS.

To accomplish these objects, both the field and the armature were made with poles, the latter having two more than the former. The field revolves and is of the C. E. L. Brown type. The armature is made of sheet-iron rings held together by bolts between cast-iron plates. The spaces between the poles of the armature were milled out after the rings had been bolted together. The field is made of two identically similar steel castings, each with five poles symmetrically spaced and pointing in the same direction parallel to the axis. The field has thus ten poles, alternating in sign, and the armature twelve. The following are some of the dimensions:

Diameter of armature pole-faces, 10¼ ins.; length of faces parallel to shaft, 4 ins.; width of pole-faces, 1½ ins.; pitch of poles on armature, 2.68 ins.; depth of poles, ½ in.; net cross-section of pole in square inches, 5.4.

The armature poles were wound with forty turns of No. 16 wire each. The double air gap is ¼ in. The field coil contains 1012 turns of No. 16 double-cotton-covered wire.

The armature coils were wound in reverse order from pole to pole in the usual way. They are connected in pairs, and the terminals of each pair are brought up to binding posts on a board on top of the machine.

An inspection of the diagram (Fig. 6) will show that diametrically opposite poles of the field are of opposite sign, while the corresponding coils of the armature are similarly wound. Hence with a closed-coil armature, the E. M. Fs. balance exactly as with a bi-polar dynamo. If, therefore, connection be made with the armature at two opposite points, the current in the external connecting circuit will be alternating. Further, two such circuits connected at right angles

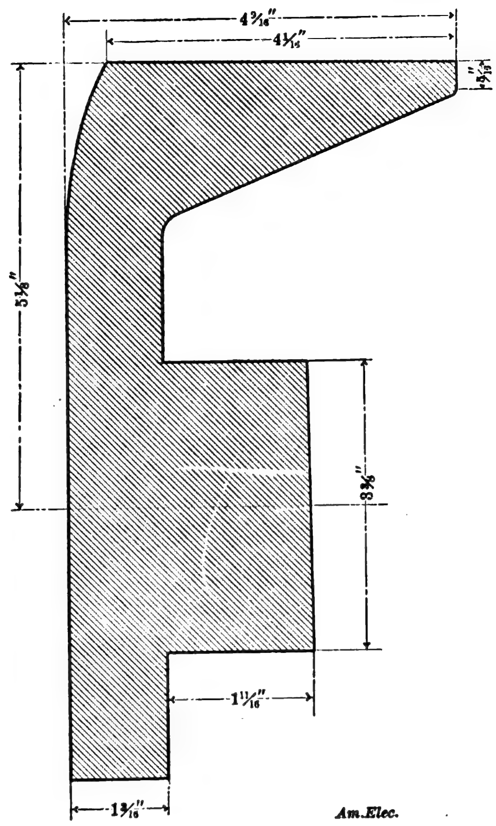


FIG. 2.—SECTION OF FIELD.

will convey currents in quadrature. By connecting at points 120 degs. apart, three-phase currents will be obtained.

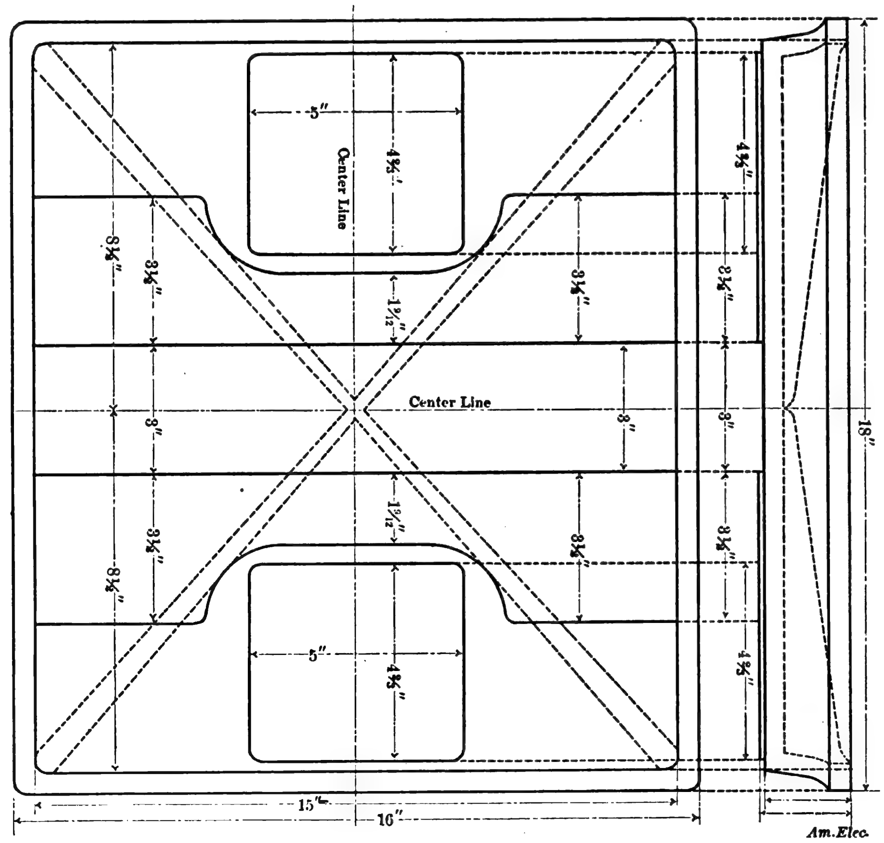


FIG. 3.—BASE PLATE.

Again, the coils may be joined either in mesh or star fashion by means of the binding posts at the top, and we may zig-zag

across either with two or three-phase connections, so as to connect opposite coils by twos or threes with no-phase difference between the two opposite groups. This connection, of course, gives the highest E. M. F.

It is evident that the phase difference from coil to coil is 30 degs. or one-twelfth of a period. Hence the voltage for a given magnetic flux cut per second, calculated in

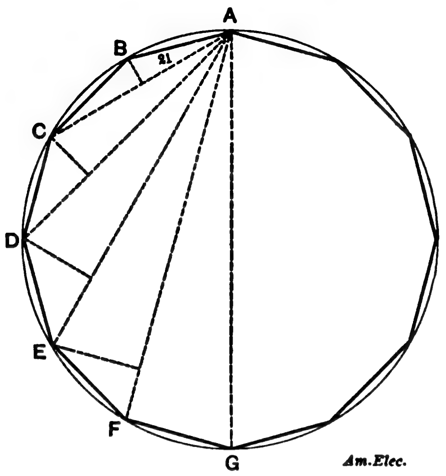


FIG. 4.—DIAGRAM OF E. M. FS.

the usual way, must be first divided by $\sqrt{2}$ to reduce from maximum to virtual volts, and then the equal E. M. Fs. generated by the several coils must be added geometrically with a phase difference of 30 degs. from coil to coil. Since the E. M. Fs. of the several coils are equal and differ in phase by one-twelfth of a period, the series may be represented by a regular polygon of twelve sides (Fig. 4). Hence, if E be the E. M. F. of one coil, the following will be the E. M. Fs. of the several groups of coils:

AC, E. M. F. of two coils, $2E \cos 15° = 1.93E$.
AD, " " three ", $E + 2E \cos 30° = 2.73E$.
AE, " " four ", $2E (\cos 15° + \cos 45°) = 3.346E$.
AF, " " five ", $E + 2E (\cos 60° + \cos 30°) = 3.73E$.
AG, " " six ", $4E \cos 15° = 3.86E$.

The phase difference between the coils reduces the E. M. F. of the six in series on either side to $3.86 \div 6$ or 0.643 of what it

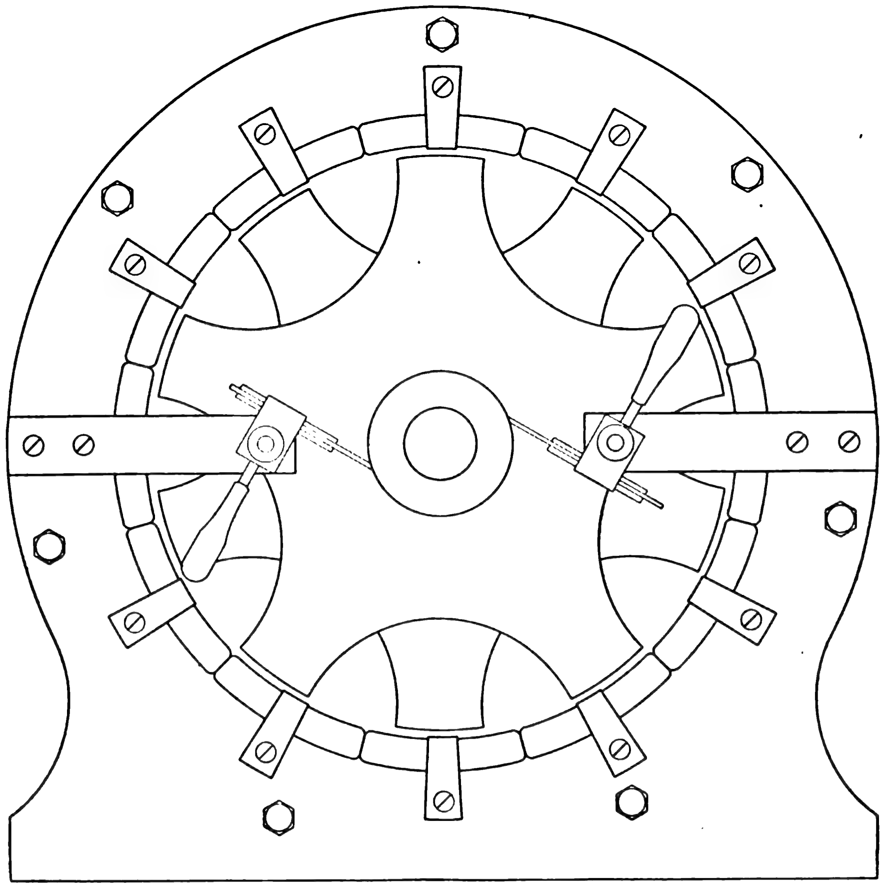


FIG. 6.—SIDE ELEVATION.

would be were there no such phase difference.

It will be seen from the subjoined table that the observed E. M. Fs. agree very closely with those computed from the foregoing equations.

	Observed.	Computed.
One coil	21	20.5
Two coils	40.3	39.6
Three coils	55.5	56
Four coils	69	68.6
Five coils	75.5	76.5
Six coils	77.5	79.1

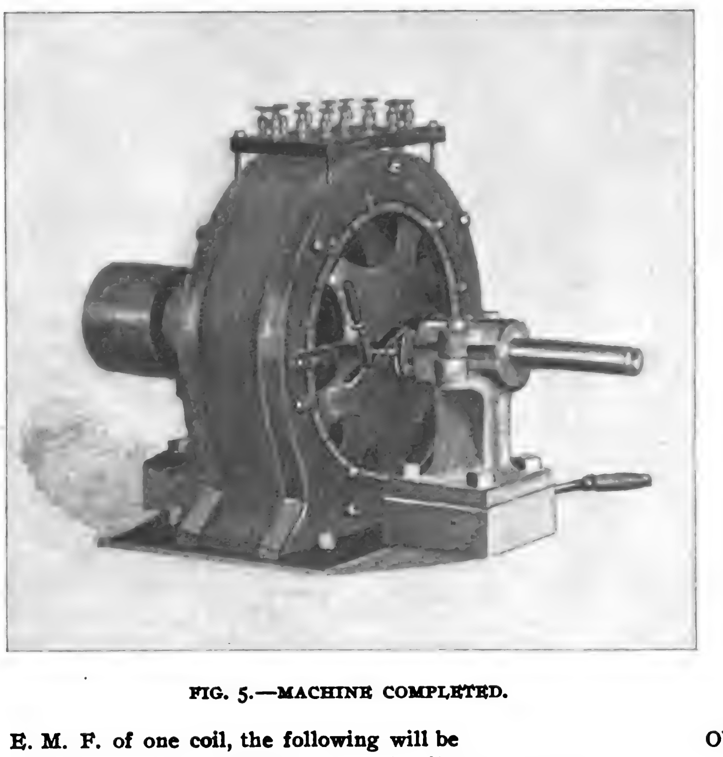


FIG. 5.—MACHINE COMPLETED.

With about 2000 ampere-turns on the field coil, the following observed voltages were obtained for the several connections described in the first column. The computed values are readily obtained from the preceding expressions.

Connection.	Observed.	Computed.
Two-phase mesh	79	79
" " star	112	112
Three-phase mesh	69	68.6
" " star	121	118.8
" " zig-zag	136	136.8

The alternator was driven by a motor on a power circuit and the voltage varied a good deal. Some of the irregularities of voltage in the generator are accounted for by the variation in speed of the motor.

The machine has a capacity of 1500 watts when connected in three-phase zig-zag mesh fashion and driven at 1650 r. p. m.

The completed machine is shown in Fig. 5, although the engraver has left off the base

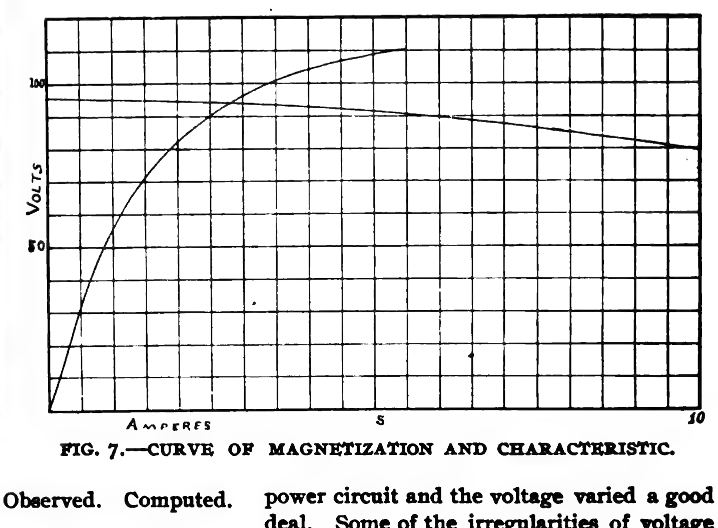


FIG. 7.—CURVE OF MAGNETIZATION AND CHARACTERISTIC.

plate on which the armature and pedestals are mounted.

Fig. 7 shows the curve of magnetization and the characteristic with 3 amperes in the field. The armature was connected as a closed coil, and only a single alternating current was drawn from it. The total drop for full load is 11 volts; of these, about 4.5 volts are due to drop in the armature, and the rest must be set down to self-induction.

FUSES vs. CIRCUIT BREAKERS.

CIRCUIT BREAKERS DEFENDED.

BY WALTER E. HARRINGTON, B. S.

Reading Mr. H. H. Cutler's article in the October issue of the AMERICAN ELECTRICIAN made my blood boil at the unfairness and speciousness of the arguments advanced.

If the article had been from the pen of any one else than a manufacturer of motor-starting rheostats, it might have been thought that the article had been based upon the real convictions of the writer. The article starts off with an attack against the common type of circuit breakers having the principle of opening the circuit as quickly as possible the instant the current becomes abnormal, and which is further designed that the greater the amount of current which flows through any particular circuit breaker, the quicker will the circuit breaker open.

The writer goes on and cites four reasons why such a design is bad. I will take up his four arguments in detail.

First. The induced electromotive forces established in the circuit owing to the quick opening are amply taken care of in the flashing or arcing provided for at the jaws or main break of the circuit breaker. It may surprise the reader to learn that more troubles have been experienced by engineers due to fuses designed to prevent arcing, thus making a barrier for the natural discharges due to induced electromotive forces, followed by the breakdown of insulation at other points.

The specific example of a shunt-wound motor across constant-potential lines having induced electromotive forces established and not protected against their effects by the opening of circuit breakers, is a very weak argument, as a shunt-wound motor of all electrical devices has embodied in its construction inherent advantages for relief, owing to its having a low-resistance armature in shunt to the high-resistance field.

Second. Stress is laid upon permitting abnormal currents to flow and then suddenly opening circuit as being comparable with mechanical inertia, water hammer, closing water valves suddenly, etc.

This line of argument is very specious, as the electric circuit has a natural cushion and easing off of load through its own arc and every provision is made to do this duty by providing carbon points for the final open-of the circuit to arc through.

In fact the carbon break followed by the gradual lengthening out of the flash or arc plays the role of the rheostat type of circuit breaker that Mr. Cutler appears to play as his trump card in the latter part of his article. The carbon break with its arc has the greater advantage both electrically and commercially of inserting resistance in circuit, in a far simpler and cheaper way than by using a rheostat as suggested by Mr. Cutler.

Third. It is certainly surprising that Mr. Cutler is not acquainted with the advantages provided in a device that will in its initial operation open the circuit more and more quickly as the current causing such opening increases—of course, followed by the cushioning and easing off of circuit through the flashing or arcing.

This is a principle in electric circuits and has been established in the well known law. enunciated by Helmholtz, shown in the following formula:

$$C = \frac{E}{R}\left[1 - \varepsilon^{-\frac{Rt}{L}}\right]$$

C—current in amperes; E—applied electromotive force; R—resistance in ohms; ε—naperian base of logarithms; t=time in seconds; L=coefficient of self induction in henrys.

This law clearly and sharply defines the necessity of opening the circuit more and more quickly as the tendency for augmented flow of current increases. As the law shows, the more quickly the circuit is opened the less the resulting flow of current will ensue. If Mr. Cutler's argument as to opening the circuit quickly were similar to the sudden chopping off of the flow of water through a pipe by the sudden closing of a valve, then Helmholtz's law and its application would be injurious as outlined, but such is not the case.

The action of the modern circuit breaker of the day is consistent with good engineering and not subject to the defects as outlined by Mr. Cutler, as Mr. Cutler has closed his eye to the fact that the arcing following the initial opening of the circuit-breaker provides the wherewithal and saving factor of the device.

It is certainly amusing in the light of the arguments adduced to look back over the history of circuit-breaker development and see how the circuit-breaker business originated and now to hear the plaintive attack by parties concerned with little petty 2, 3, 5 and possibly 10-HP protection. The magnetic circuit-breaker business in this country was brought about by the grave and urgent necessity of protecting railway power circuits and generators in units aggregating 500 to 1000 HP, where the fuse by its inherent defects, by permitting such outrageously enormous current flow, fell down by the natural law of the survival of the fittest. It was only after several years that engineers by actual experience learned the manifold advantages of circuit breakers and began to use them upon lighting circuits. This now is the practice of engineers of the highest standing.

The reason circuit breakers are preferable to fuses even in the extreme case of elevator-motor protection is due to the uncertainty and unreliability of fuses, in connection with their notoriously bad quality of permitting such enormous current flow in event of a short circuit.

Fuses below 10 amperes in capacity are not objectionable, but as the capacity of the current increases, the importance of using magnetic circuit breakers increases, as is borne out by the following empirical law established by the writer several years ago—wherein in any metal or alloy the amount of current flowing through same during act of fusing in event of short circuit upon 500-volt circuits is equal to its area divided by a constant dependent upon the kind of metal; for instance, for copper the law by formula is,

$C = \frac{A}{1.9}$ wherein C = current.

A = cross section in circular mils.

The practical application of this law is illustrated well in the case of No. 14 B. & S. gauge copper wire, which will fuse in a short time with a current flow of 168 amperes—whereas a short circuit will permit a flow of 2053 amperes as derived from formula

$$C = \frac{cm}{1.9} = \frac{4106}{1.9} = 2053 \text{ amperes.}$$

HOW SHALL ELECTRICAL APPARATUS BE PROTECTED?

BY JOSEPH SACHS.

Electrical apparatus, whether dynamos, motors, arc or incandescent lamps, or the conducting systems which supply current to these generating and translating devices, all have what may be called a maximum continuous operating capacity at which they are rated to work satisfactorily, although frequently designed to go above this rating. Excessive current demanded of the dynamo, supplied to the motor or transmitted through the conducting system, gives rise primarily to excessive heat, which follows a law that must be most carefully considered in this protection problem.

In addition to the injurious thermal effect of the overload current, dynamo-electric machinery may be subjected to severe strains which are likely to seriously affect the machine electrically and mechanically.

A protective device should act when the gradually increasing supply or output of current has attained a certain maximum, beyond which serious effects are likely to result from a long-continued operation at this point or a further increase. It must also instantly cause a cessation of current supply in cases of so-called short circuit, where the resistance of the circuit, having perhaps been reduced to a minimum, the resulting rush of current, even if only instantaneous, would frequently be fraught with dire disaster to generator and engine, and with even a small time interval, to the conducting systems.

Time may elapse in the first case during which the injuriously large current is permitted to flow, but in the second case, it is essential that the protective device should work practically instantly at a point which will prevent the short-circuit rush of current from attaining anything but a small percentage of its possible maximum.

A device which will comply with the above conditions will essentially have a variable time cut-off, ranging from the minimum overload opening current with the maximum time interval, to the instantane-

ous short-circuit opening point. The relative proportion of maximum continuous running current to minimum cut-off current, is dependent upon the type of apparatus to be protected. Generally it is highly desirable, however, to bring these points as close together as possible and to allow a time interval of cut-off in inverse relationship to the current.

Does any protective device which does not take into consideration all of the above conclusions, satisfactorily perform its intended function? Which would seem to be superior, judged from the general standpoint of *electrical* protection, and not on account of peculiar advantage for any special condition? A protective device which simply cut off the current when a certain overload current was reached without taking into consideration any time, and working only and instantly at this point, or one which operated on the lines above stated, allowing a fixed current and time safety factor for the apparatus to be protected? Why not protect the apparatus against the *effect* of the current and not simply the current? If so, time must be considered as an important factor in the result. Does an instantaneously operated device for the protection of electrical apparatus against excessive current effects, appear more appropriate than a safety boiler-protecting mechanism which damped the fire when the amount of water in the boiler reached a certain quantity?

For the protection of electrical apparatus from excessive currents, two distinct methods have been developed—the fusible cut-out and the magnetic circuit breaker. The fuse depends for its operation on the same heating effect of the electric current against which it is intended to protect the apparatus supplied therewith. The circuit breaker, in its present commercial form, depends solely upon the magnetic effect of the current. In the one case the protecting medium considers not only the current, but the time of its duration. In the other various manufacturers have vied with each other in producing instantaneous operation.

Since the very earliest commercial development of multiple varying current electrical distribution, the fuse has been one of the most essential elements of success. One of the very simplest elements of the entire system, it has been neglected and considered in the light of a minor detail, when really it possessed the basic principles of the ideal protection for electrical apparatus, of every description, it may even be said. On the other hand, the electromagnetic circuit breaker, although by no means a new comer, has recently attained particular prominence owing to its peculiar adaptability to certain conditions where it is essential to provide a rapid means of renewing the continuity of the circuit, and also from a certain misconception of the actual functions of an electrical protective device.

Fuses have manifold ills. The present type of fuse is, in fact, a "necessary evil." Why, however, should present types of fuses. without any regard to rating, length, location, connection, arrangement and surroundings, be expected to give satisfactory results, when it is found to be essential to most carefully graduate and calibrate an electromagnetic circuit breaker?

Basically, the fuse involves a principle which allows of far closer and more delicate standardization than the simplest circuit breaker which has yet set itself up as its successor. Circuit breakers are efficient only when well constructed, calibrated and maintained. Fuses are expected to give equally good service, though but few attempts have been made in the past to give them any accurate refinement. The well known fuses of to-day are the fuses of the beginning, and their use as at present practiced, a makeshift. Would it not be well to consider fuse possibilities before regarding this most simple of all automatic electrical devices as deficient and inferior? By no means have the possibilities of the fusible cut-out been exhausted. In fact, it needs but a short step to almost entirely eliminate all of its objectionable features.

The many shortcomings of the common type of fusible cut-outs have enabled the circuit breaker to advance until some of its advocates are enthusiastic enough to tell us that magnetically operated switches—circuit breakers—are to entirely displace fuse cut-outs. Their use is recommended, and even in some cases demanded, when the results must be detrimental instead of advantageous.

Circuit breakers have certain fields where their use is perhaps desirable, not because they afford a better electrical protection, but because they have other features which are worthy of consideration in these peculiar instances. The writer is bold enough to assert, and this assertion is based upon more than theory, that wherever it is desired to protect electrical apparatus from injurious current effects, a *properly* constructed fusible cut-out (considered as a protective device solely) serves far better, or at the least, as well, as any form of instantaneous circuit breaker. When aside from their actual efficacious operating ability we consider the structural, economical and other relative features of simplicity of both devices, how vastly superior does the fuse appear.

What warrants the assumption that the circuit breaker is superior? Electromagnetic circuit breakers as to-day constructed, embody practically two elements—a switch closed against the action of a spring, and an electromagnetic trip mechanism holding it until the current reaches the set point. When it does, the device opens with the utmost rapidity, making due allowance for the necessary care and attention to keep it in fairly good condition.

We are told that this instantaneous operation is a most highly important feature, one to which the circuit breaker greatly owes its success. Strange, is it not, that notwithstanding this, almost every circuit-breaker manufacturer is trying to produce some form of electromagnetic circuit breaker which shall have the happy faculty of taking time into consideration. Such an instrument would certainly be vastly superior to the present circuit-breaker, but could this result possibly be accomplished in an electromagnetic switch with any approach to the simplicity inherent in the fusible cut-out, which already gives us this effect?

A fuse—and when we consider fuses here, we are considering those built on correct lines —is the very perfection of simplicity. Compare a time-interval, or, in fact, any circuit breaker with it? We are told about the constancy of the circuit-breaker mechanism which, if coupled with time-interval operating ability, would make an ideal combination. When the author of a recent paper states that: "The ideal circuit breaker depends upon the combined magnetic and heating effect of the current," he should tell us what good the magnetic effect of the current is to serve, when the simple fuse uses the latter effect only, to accomplish the same results. How can it possibly be good engineering to adopt an expensive and comparatively complicated device to do exactly that which can be accurately accomplished by one far simpler and cheaper? The latter has advantages aside from its operating ability under the same conditions, which cannot even be approximated by the electromagnetically operated time-interval switch when it arrives.

For the present we must consider the ordinary type of circuit breaker which is an expensive luxury, but once installed it remains without further expenditure, serving its purpose many times. This is to be fully appreciated only if the switch element is so constructed as to minimize heavy arcing and flashing at large overloads and short circuits. Carbon breaks and magnetic blowouts are found to be essential, and even with these the switch blades frequently retain the results. On the other hand, fuses need replacing, but not as often as a circuit breaker would open if set to protect for the same current, simply because the circuit breaker does not consider the time during which the current exists. Consider how many fuses could be replaced before the entire cost of the circuit breaker would be reached.

Such a condition may only be reached when *time-interval* overload and short-circuit currents are very frequent. In this case the circuit breaker may have an economical advantage, and perhaps also, owing to its ability to rapidly renew the connection, may be desirable.

Now as to fuses. The writer does not intend to imply that the present form of fuse and the methods adopted for its utilization are capable of giving results which would warrant the assertion regarding the superiority of fusible over magnetic cut-outs. It is quite true that the present form of alloy fuse wire or link of varying length is used indiscriminately in cut-out blocks of 101 different designs, with a vast variety of terminal arrangements, leaving the fuse after it is placed in them so that it is not only affected by its disposition in the cut-out block, but is exposed to exterior conditions which affect its working ability. How can we expect safety from a suddenly volatilized mass of metal and the ensuing arc? Even if all these conditions and arrangements of the fuse were standardized, we certainly cannot obtain definite results without having a definite fuse rating. Of several different makes of, say, 25-ampere fuse links, all will carry 25 amperes, but no definite information is given on any one as to its blowing point. There seems to be an arbitrary rule followed by different fuse makers in regard to allowing a certain percentage of overload current before blowing. Generally it will be found

that common fuses are rated at about one-half of their actual continuous carrying capacity. Satisfactory results are certainly impossible by fusing for 25-ampere continuous running capacity with a so-called 25-ampere fuse without even knowing in what time the minimum blowing current above the maximum carrying point will act.

Why should the fuse have any such peculiar rating? Would not the proper method be to rate it at its maximum continuous carrying capacity and at the percentage of overload blowing current, and let the time interval in which this current acts, depend upon the particular service for which the fuse is intended? Assuming that we have a reliable fuse wire of even composition and cross-section, the radiating surface, length, terminals, contact clamps, terminal block and location of fuse in same can easily be made fixed quantities. The effect of the environment, the tendency to deteriorate and to flash and arc when operating, and a non-interchangeable arrangement between fuse and fuse block, are important considerations. Owing to an almost complete disregard of the above elements, upon which the satisfactory operation of this device depends, fuse cut-outs have no fixed melting point, cannot be accurately timed, rapidly deteriorate and, last but not least, are subject to most dangerous arcing and flashing when operating with heavy loads.

Much has recently been said regarding the surrounding of the fuse by a fixed environment held about the wire by an exterior tube. Such an arrangement at once fixes the different variables, and in one device now on the market prevents any exterior flashing or arcing of the fuse. It is in this direction that success can be attained by fusible cut-outs. The device above mentioned accomplishes excellent results, but the fuse actually blows in an air chamber, inside of the enclosing jacket, and therefore still retains some of the objections of the air fuse aside from its bulkiness and high cost.

Some years ago the writer devised a fuse which is of the enclosed type. Recently he has taken up this line of development quite extensively and attained highly satisfactory results. This fuse as now perfected, is small, almost as cheap as any ordinary link fuse of the same length, can be short-circuited or blown at heavy overload without the slightest noise, flash or arc, and can be built to blow, if desired, at 10 per cent. or even less above its continuous running point.

The peculiar construction of this new fuse is such that all variable factors, due to the gradual melting to the breaking point, of the length of air-suspended fuse are eliminated. Any air-surrounded fuse will arc under certain conditions, although this arc may be extinguished and not appear on the exterior. The fuse in question does not arc.

It is believed that the working of an air-suspended fuse at 10 per cent. or perhaps less overload in a short-time interval would be almost impossible. Reliable fuses such as the above, whose one-second operating point leaves a certain time factor of safety in the apparatus to be protected, unless for other reasons electromagnetic switches are desirable, should answer the question at the head of this paper.

The relative value of reliable flashless fuses as compared to circuit breakers in certain specific instances may be slightly considered. Take, for instance, an electric generator to be protected from overload or short circuit. The fuse certainly best meets the conditions for gradual overload protection. With a sudden abnormal rush, however, we have another possibility of injury, as has been noted—the sudden tendency to stop the dynamo and engine and strain it mechanically and electrically. The generator may supply a system whose current demands are constantly varying, taking at times sharp jumps far above the maximum output of the machine. In either case, circuit breaker or fuse, the amount of current rush will depend upon the relative time interval of current increase and protective-device operation. At such current rushes as result from short circuit the time of increase is infinitesimally small and the current has reached far beyond the setting of the breaker at the instant it operates, even though it be a practically instantaneous device. That a properly constructed fuse will go at almost the same instant the writer has demonstrated by connecting in series a circuit breaker and an improved fuse, both set for the same constant running capacity, and short-circuiting both protecting devices across a source of large supply. The circuit breaker did not protect the fuse. If, therefore, the fuse acts as quickly as the electromagnetic switch under these conditions, the only remaining advantage the latter has is its ability to rapidly renew the circuit.

This may be a desirable feature on switchboards in electric-railway and some electric-lighting stations, but even here magazine fuse devices may be built to accomplish almost similar results. The fact that the rapidity of operation of a fusible cut-out is as the square of the current, is notable in this connection.

The use of electromagnetic circuit breakers to protect motors, whether stationary or otherwise, has recently attained some prominence. No more fallacious combination could be thought of than a motor built to stand a fairly large overload for a time, as nearly all motors are, and requiring in many instances excessive starting currents, and an instantaneous circuit breaker. The breaker must either be set at a point where it does not open at frequent, sudden, short overload demands of current by the motor, or so low that it is constantly stopping the machine. In the first case it is set beyond the current which, continued for a time will injure the motor, but not affect the circuit breaker. In the second case, its employment soon results in convincing the user of the motor that something or other is some kind of a nuisance, particularly if he has work to do which necessitates short excess efforts on the part of his motor power. The actual outcome of such combinations we see in tied-up circuit breakers and then, woe to that particular motor. Fortunately, however, those who recommend such protection are careful to also require fuses. Far more injury will be done to any shunt motor in an instant by throwing its armature directly across the line in starting with the load connected than could be done by permitting an overload of, perhaps, 100 to 200 per cent. for one-half to one minute.

Certainly circuit breakers are not essential to the welfare of arc or incandescent lamps. While the current in the former may vary slightly, the current line of the latter is practically straight after the lamps are started. For such work a circuit breaker might serve effectively.

Current excess in incandescent lamps is, however, practically impossible except when due to excess of voltage, and it is the aim in all plants, isolated or central, to keep the latter constant. Protecting devices are therefore installed not to protect the lamps supplied, but the supply conductors whose insulation may be affected to any degree up to the short-circuit point, allowing excessive currents which affect the conducting system thermally entirely. They can therefore best be protected by an electrothermal device, such as a safe and reliable fuse.

A recent article tells about a circuit breaker which gradually introduces resistance instead of suddenly rupturing the circuit and allowing a possibility of that induced E. M. F. effect which is dangerous to the insulation. First, let us remember that such effects are only prominent on inductive circuits in which the entire current is suddenly cut off. To protect large dynamos and motors, particularly the former, such a plan is advisable. It is now being accomplished in electric railway work by connecting a resistance in shunt across the switch contacts of the circuit breaker. The same methods may be adopted in the use of a fuse cut-out.

In conclusion, another question may be asked. Is the protecting device to guard against injurious electrical effects, or is its adoption generally dependent on other features? The use of one effect of the current to guard against results due to another certainly cannot be basically correct.

THERMO-ELECTRIC BATTERIES.

To the Editor of American Electrician:

In Mr. Reed's answer to my last letter upon the operation of the Jacques cell I find the following, which is apparently the key to the difference between us. After quoting a statement of mine, Mr. Reed says, "Does he really mean that in the Jacques cell the free oxygen constitutes either the anode or the cathode through which the current passes into or out of the cell?"

I do mean that some of the oxygen that is forced into the Jacques cell goes into solution or in some other way comes into electrical connection with the iron electrode, combines with the positive ion of the electrolyte in strict accordance with Faraday's law, and is the medium by which the current reaches the iron electrode and so passes out of the cell. This has been my view from the very beginning of this discussion, and I am at a loss to understand how any one familiar with the theory of electrolysis, could have failed to see in my first letter that such was my understanding.

I conclude from the form of Mr. Reed's question that he would look upon such a view as wholly inadmissible. To my mind, in no other way can the behavior of the Jacques cell be explained. What are the

facts? Oxygen is forced into the cell through the iron electrode. While the oxygen is flowing a powerful current is developed; stop the flow of gas and the current *immediately* falls to a fraction of its former value. Re-establish the flow and the current *at once* increases, and this is true whether the gas introduced be cold or hot. Mr. Reed says the free oxygen bubbling through the electrolyte of the Jacques cell can have no direct effect upon the current. Of course not. It is not the oxygen that bubbles through, but the oxygen that does *not* bubble through that affects the current. I have proved by direct experiment that, other things remaining the same, more oxygen bubbles through the electrolyte when the circuit is open than when it is closed.

These two things, the great increase of current when oxygen supplied through a red hot tube flows even very slowly into the electrolyte, and the disappearance of oxygen when the circuit is closed, are to me positive proof that the oxygen in the Jacques cell does come into electrical connection with the cathode and does perform the same function as the depolarizing elements in two fluid cells. Mr. Reed says that such depolarizing elements are always distinct chemical compounds. How is it with the Grove gas battery? Is not free oxygen there the depolarizing element? Is it not consumed "in strict accordance with Faraday's law?" Is not the energy of the cell the energy of combination of oxygen and hydrogen, exactly as though no electrolyte intervened?

If two platinum electrodes be inserted in the two branches of a U-tube filled with dilute sulphuric acid, and if oxygen be introduced into one branch so as to bubble up alongside of one electrode, and hydrogen into the other, so as to bubble up alongside of the other electrode, a current will flow on joining the two electrodes, the oxygen being positive and the hydrogen negative. Reversing the two gases will reverse the current. Stop the oxygen and the current will soon cease. This experiment will succeed better with platinum wire-gauze electrodes, and better still if the electrodes are platinum-gauze baskets filled with platinum sponge through which the gases are compelled to pass.

Again, place a zinc electrode in one branch of the U-tube and close the circuit through a small resistance. Hydrogen escapes from the platinum basket. Now connect to a Weston voltmeter. This will indicate about .7 volt. Now run oxygen into the basket. The potential quickly rises to 1.5 volts.

In these cases gaseous oxygen is certainly brought into electrical contact with the electrode; it as certainly acts as a depolarizer as do the chemical compounds, and the energy of its union with the hydrogen is certainly added to the electrical energy of the cell.

Mr. Reed compares the oxygen introduced into the Jacques cell to copper filings thrown into a plating bath. Suppose the plating bath to have a tubular platinum anode through which the copper filings are injected. Some of the filings may come into electrical contact with the platinum and will then behave exactly as though they formed a part of a copper anode; all the energy relations will be the same as for a copper anode. If more filings are introduced than are needed for combination with the negative ion, they will go out into the cell and be wasted. So with the oxygen of the Jacques cell, some of it comes into electrical connection with the iron electrode. As much as is needed combines with the positive ion; the remainder bubbles throu gh the electrolyte as so much waste.

Mr. Reed's spent Daniell's cell illustration is not well taken. It is not a parallel case. The zinc element at the temperature proposed combines with oxygen much more freely than does copper. SO_4 is required to combine with the copper, and Mr. Reed proposes to supply oxygen. Supplying oxygen, oxide of zinc must be formed which is nearly insoluble. Copper at ordinary temperatures has very little affinity for oxygen. But notwithstanding all this, if platinum be substituted for the zinc, and oxygen be supplied through it, *a current will flow, and copper sulphate will be formed.* This current stops when the supply of oxygen stops, or as soon as that which is occluded in the platinum is exhausted.

Mr. Reed's "man lifting himself by his boot straps" illustration, is another case which does not fit. The parallel would be—a cord attached to the boot straps and passing over a pulley, at the other end of the cord a counter-weight just sufficient to balance the man. So far nothing occurs. But supply a force to lift the man, the falling counter-weight furnishes *all* the energy required to raise him, and the force that puts the system in motion is *entirely* employed in doing other work. This is the exact parallel of the energy relations in the Jacques cell.

As to the E. M. F. to be expected, it must be remembered that it is potassium carbonate, and not carbon dioxide that is formed.

Mr. Reed asks what source of energy he has omitted. Again, I say he has omitted the union of oxygen with the positive ion. This is the reaction as I see it.

Iron. | Before. | Carbon.

$$2O + 3KHO + C$$

After.

$$\left.\begin{matrix} KHO \\ H_2O \end{matrix}\right\} + K_2CO_3$$

Mr. Reed would have the *K* and *H* set free. I have them combined with oxygen. That the *K* and *H* do combine with oxygen is certain. That the energy developed by that combination is added to the electric circuit through the electrical connection between the iron electrode and the oxygen is to me just as certain.

Now, as to the observed E. M. F. and the energy developed in the Jacques cell. If these, after including all sources of energy, prove to be greater than can be accounted for upon data at present accepted, and upon views now held as to the valency of carbon, I should certainly subject those data and views to new tests before accepting a theory that derives the energy directly from heat by means of an apparatus and working substance in which there is no difference of temperature and no distinction of source and refrigerator. W. A. ANTHONY.

New York, N. Y.

To the Editor of American Electrician:

Prof. Anthony now correctly admits, in the second paragraph of the above communication, that the only oxygen which could, by galvanic action, oxidize the carbon of the Jacques cell, comes from the decomposition of the electrolyte. His statement that the oxygen which is forced into the cell "combines with the positive ion of the electrolyte" is also correct, though this combination has nothing to do with Faraday's law. It is a simple case of combustion or oxidation, the reduced metallic iron, as pointed out by Prof. Elihu Thomson, being re-oxidized to ferric oxide or potassium ferrate. But, inasmuch as the oxygen and the oxidized body in this reaction are not connected by any electric conductor other than the electrolyte, it is evident, as Prof. Anthony now admits (see AMERICAN ELECTRICIAN, October, 1897, page 392), that this reaction between the oxygen and the reduced iron cannot evolve any electrical energy. It can evolve only heat-energy. Therefore, the source of electrical energy which Prof. Anthony has throughout this discussion insisted upon so strenuously and accused me of ignoring so often, viz., that furnished by "the union of oxygen with the positive ion" of the electrolyte, now appears by his own admission to be only a source of heat. I would respectfully call Prof. Anthony's attention to the fact that, instead of ignoring this source of energy, I was the first to point out its function in the Jacques cell. This I did in various communications published in the electrical journals about a year ago. From one of these communications I quote as follows:

"It is also to be considered that, as a thermo-electric couple, this cell differs in an important particular from thermo-electric junctions between metals. In metallic couples the efficiency is limited by the second law of thermo-dynamics, because the only source of heat is the difference between the heat received from without and the heat which is again rejected. But in the case of the Jacques cell we have the peculiar circumstance that oxidation of iron is going on within the hot junction, and the resulting heat (which is greater than that obtainable from the combustion of an equivalent of carbon), is actually evolved within the hot junction, instead of being absorbed from without. What becomes of this heat? It certainly does not escape, and it is sufficient to raise the temperature of the hot junction far above that required to give a possible efficiency of 32 per cent. This heat is also exactly equal to that required by the reduction of another equivalent of iron to the metallic state. There is no apparent reason for denying that an equivalent of metallic iron may be oxidizing and giving up its heat to the hot junction, while an equivalent of ferrate is being reduced with absorption and transformation of this energy at the cold junction, especially since it has been found that metallic iron is being constantly oxidized in contact with the cell wall. The combustion heat of this iron amounts to 1.27 times the energy of the carbon consumed in the cell, and to 84.5 per cent. of the heat evolved on the grate, according to the figures given by Dr. Jacques."

"On this theory, that the heat evolved by

the oxidation of metallic iron in the hot junction is transformed at the cold junction into chemical energy in reducing iron, the electrolytic oxidation of the carbon would add all its energy to that of the electric circuit without loss of any kind, as in all other electrolytic oxidations. This would account exactly for the 1.04 volts obtained by Dr. Jacques and seems to be the only way in which it can be accounted for. The validity of this theory is also entirely independent of the value of the formation heat of potassium ferrate."

The only possible sources of energy in the Jacques cell are, therefore, as finally admitted by Prof. Anthony.

1. The energy of carbon oxidized within the cell.

2. The heat-energy evolved within the cell by the oxidation of reduced ions.

3. The heat energy absorbed from without.

I have shown in a former communication,* that the first of these sources of energy is insufficient to cause decomposition of the electrolyte, and hence, cannot evolve, but must necessarily absorb, electrical energy. An electric current could pass through the cell, therefore, only by the application of electrical energy from an external source or by the transformation of heat into electrical energy. The external source of electrical energy is excluded by hypothesis, and we have left no possible source of current, except thermo-electric inversion.

The admissions which Prof. Anthony has now placed on record, together with the inevitable conclusions to which they lead, leave nothing further for discussion. We appear not to have differed in our opinions at all, according to Prof. Anthony's statements, but only to have misunderstood each other.

In closing this discussion I may remark that no such reaction takes place in the Jacques cell as that given above by Prof. Anthony. Translated into an equation of the ordinary form, it would be

$$2O + 2KOH + C = H_2O + K_2CO_3.$$

The formation of potassium carbonate in the cell is incidental and subsequent to the formation of CO_2. It forms very slowly, requiring according to Dr. Jacques, weeks or months to carbonate a few ounces. If the evolution of electrical energy depended upon the above reaction, the weight of possium hydrate consumed, that is, converted into carbonate, would be 9.33 lbs. for every pound of carbon consumed in the cell. This would be a rather expensive method of getting "electricity direct from carbon."

C. J. REED.

*AMERICAN ELECTRICIAN, August, 1897.

CONVENTION OF THE AMERICAN STREET RAILWAY ASSOCIATION.

The sixteenth annual convention of the American Street Railway Association, held at Niagara Falls, Oct. 19-22, was a successful meeting in every respect. The registered attendance alone was over 1000. The exhibits were very complete, and generally disposed in an intelligent manner that admitted of the most benefit to be derived from their inspection by delegates. The average excellence of the papers read was high, those by Messrs. Hewitt and Hoopes and Colonel Heft being particularly appropriate for the occasion, not only in subject and timeliness, but also in manner of treatment.

A feature of the convention was the meeting of the young Street Railway Accountants' Association at Niagara, by invitation of the older body, the sessions of the two bodies being held simultaneously in the same hall. This was the first annual convention of the Accountants' Association, and mnch interest was displayed at its sessions, the discussions, in fact, being much more extended than those of the American Association. Papers were read by Messrs. J. F. Calderwood, C. L. Wight, W. G. Ross and F. R. Henry, and an elaborate report presented on a "Standard System of Street Railway Accounting."

In his opening address, President McCulloch in referring to the ut litarian use to which Niagara Falls has recently been put, remarked that the enabling element for the use of their wasted energy is electricity, and "to learn more of this revolutionary factor in the street railway business, to discuss this and other kindred subjects, to compare our experiences, to meet and greet each other, to renew old friendships and acquaintance, and to form new ties, to be forced, if need be, to recognize that 'that there are other pebbles,' to find that the American Street Railway Association is filled with men to know whom is both an honor and a pleasure—these, my friends, are some of the things which have brought us together, and it is hoped that a full measure of pleasure and profit will reward all who honor us with their presence."

President McCulloch also paid a deserved compliment to the commercial element, which so largely enhances the value of the convention to delegates by exhibiting to them the apparatus and appliances embodying the very latest advances in the art. "Our noble ally," he said, "our helper in all the good work we accomplish, our always alert, jovial and genial friend, the supplyman, has contributed, as usual, his share to our entertainment and enlightenment. He is here to show us the best of everything he has. He is not, in one sense, a member of our association; he does not participate in our deliberations; but he stands at our threshold, and the vigilance which he exercises, that none may escape, is worthy of our emulation in the conduct of our business. Let us show our appreciation of his efforts by inspecting his wares, by loading him with orders and by fraternizing with him, that his enjoyment of the occasion may be equal with ours."

The report of Secretary T. C. Penington showed the association to be in a flourishing condition financially, there being a surplus of $4571. As Mr. Penington entered upon his duties as secretary in 1895 with a deficit of $4808, it is quite evident that the association has confided its administrative affairs into competent hands.

Below will be found abstracts of all the papers read at the convention, except that by Mr. W. J. Hield on the "Best Method of Settling Damage Costs and the Prevention of Accidents by the Use of Fenders or Otherwise."

The officers elected at Niagara for the ensuing year are Albion E. Lang, president; W. Caryl Ely, first vice-president; John A. Rigg, second vice-president; E. G. Connette, third vice-president; T. C. Penington, secretary and treasurer. Boston was designated as the next meeting place, the date of the convention to be decided later.

In a paper on "Municipal Ownership and Operation of Street Railways," Mr. P. F. Sullivan discussed the subject matter in a temperate manner, contenting himself to illustrating by quotations from authoritative sources the present conditions of municipal maladministration and corruption throughout the country. He did not consider that

ALBION E. LANG, PRESIDENT AMERICAN STREET RAILWAY ASSOCIATION.

success of municipal ownership in a few instances abroad can have any bearing in this country, for the reason that not only are the methods of municipal administration there totally different, but also because the other conditions are also widely different. He pointed out one very important difference in the conditions, and that is, the tendency of American street railways toward extensions into and beyond the suburbs, and the rule of charging but a single fare from the most distant point. In foreign railways under municipal ownership, the tendency is to confine the railways to the more thickly settled and profitable districts, and charge an extra fare for lines extending beyond these; the result being to limit electric traction systems abroad much below what would be possible in this country.

Mr. George W. Knox read a paper on "Some of the Difficulties Existing in the Construction and Operation of Electric Street Railways." He laid great stress upon the wisdom of careful selection of employes' from the head foreman down to the men sweeping the depot, and spoke highly of the benefits to be derived from state railway associations, to the meetings of which companies may send men at the head of the different departments to benefit from the dis-

cussion of plans for better methods of carrying on work. He also recommended the practice of calling together the heads of the different departments at regular intervals for consultation and exchange of opinions. A company should not lightly make changes, whether in heads of departments or operators; new men are naturally inclined toward reorganization and the introduction of ideas which, while successfully tried elsewhere, may not be suited to a new set of conditions. The subject of motormen was dwelt upon; Mr. Knox said he did not believe in attempting to educate motormen to any extent in electrical knowledge, believing that in case of trouble it would be better to call for an emergency crew or send a disabled car to the depot; if they understand the brake mechanism, the proper manner of handling the controller, how to cut out a disabled motor, and the rules as given in the road rule-book, they will have about all they are able to master.

Mr. Knox considers that every road should be its own designer of everything possible, getting out specifications and checking up carefully the material received, the specifications going into detail for every piece of apparatus required. A multiplicity of records is deprecated, Mr. Knox believing that much valuable time is lost and money thrown away by roads which keep numerous sets of records; he believes that the man in charge of a department should be able when called upon to show exactly what it is costing to perform any part of work under his charge, which knowledge he should be able to have without the constant keeping up of a lot of records.

In the discussion ot Mr. Knox's paper, Mr. H. H. Littell, of Buffalo, said that for a good many years he had been having consultations every morning among heads of departments of his road, and that the practice had been attended with a great deal of good to his company and benefit to the public.

Mr. Charles Hewitt read a paper on "Application of the Storage Battery to Electric Traction," in which he considered the subject under three heads: The application of a battery direct to a car or locomotive; its application at points on the line distant from the generating station, and its application in the power house.

After discussing the application of the battery direct to a car or locomotive, Mr. Hewitt concludes that, while not wishing to seem pessimistic, he must confess that to him the outlook for the battery car is not bright, and he does not look for much improvement unless some combination of elements be discovered whose characteristics are very different from those of the lead battery.

As to the application of storage batteries on the ends of long lines, he considers this method of power distribution, while not economical in itself, yet may lead to great economy under certain conditions. Such favorable conditions existed in the case of one of the roads of the Philadelphia Traction Company, where a line had been extended such a long distance that the drop in pressure made it impossible to run the requisite number of cars at the proper speed. In this case a storage battery was installed 5 miles distant from the generating station, and two cables run to it, which we shall call No. 1 and No. 2. No. 1 cable connects with the bus-bars at each station and feeds along its length into the trolley; cable No. 2 runs direct to the battery bus-bars and at the power house has a booster in circuit. Under ordinary conditions the current in cable No. 2 divides at the battery station, part feeding into cable No. 1 and part into the storage battery; when, however, the load becomes very large, all the current from cable No. 2 passes into cable No. 1, owing to the fall of pressure in it, and in addition the battery discharges into the same cable. By this means very even presssure is kept up over the line. The entire cost of the storage battery adjunct was very much less than would have been any other provision for obtaining equally satisfactory results.

As to the application of the storage battery in the power house, Mr. Hewitt is confident that as its advantages become better known the practice will become more general. In this case the battery becomes a load regulator, enabling the generating machinery to be run at full capacity at all times, thus increasing its efficiency; it also reduces the amount of machinery necessary, as it will take care of periods of excessive load that otherwise would require additional generating machinery. An instance is quoted where three generators were used with a storage battery where four were required without it, with also an increased efficiency.

In the discussion of Mr. Hewitt's paper, several questions were asked as to the practicability of using a storage battery to furnish all the current for an electric railway during certain hours, shutting down the generating machinery during these hours. In reply, Mr. Hewitt said that the storage battery of to-day is entirely reliable, and could be used for that purpose with perfect success; the only question entering is that of cost, which must be decided for each case in order to determine the commercial feasibility.

In a paper on "Power Distribution and the Use of Multiphased Current Transmission for Ordinary Street Railways," Mr. Maurice Hoopes discussed very fully the different systems of electric-railway power transmission aside from the one in general use. He considers that the use of alternating current for ordinary electric railways is limited to the rotary-converter system, for the reason that alternating-current motors in the present state of development are not adapted to the needs of ordinary electric railways, though adaptable for express service between cities.

While in his opinion most cases may be best handled by direct-current distribution, there are, nevertheless, instances where none but the alternating-current is applicable. For example, where water power is used, the generating point is almost always so remote from the center of load that very high potentials must be used for economical transmission; and long interurban roads operating so few cars as to call for but one power station, implies a condition where distribution may best be accomplished from sub-stations on the alternating system.

He believes that the three-wire system is only applicable when there is an excessive track loss and with fair opportunities for balanced load. The booster, he states, has a much more general application than the three-wire system and is suited to a greater number of cases than any other special system; but where the work can be handled by a special generator run at increased voltage and supplying a definite section and no other load, this admits of a considerable saving over the booster, and the method is also preferable from its simplicity.

In the discussion of Mr. Hoopes' paper, Mr. Hewitt said that the booster and storage battery would in many cases be found more economical than alternating currents and the rotary transformer for delivering power at a point distant from the generating station, provided this distance was not excessive. He stated that it was a question in his mind whether we are not on the eve of a very successful three-phase motor, which will obviate the use of rotary transformers, as the alternating current will then be stepped down by static transformers and fed direct to the trolley line.

In a paper on "Discipline of Employes," Mr. George H. Davis, after advancing general consideration on the subject, detailed a system employed by the Canal & Claiborne Railway Company, of New Orleans. In all departments of this road employes are placed upon a basis of competition, or civil service régime. Men are employed who have the best standing according to a broad competitive examination, and are placed in the lowest rank of any given branch of the service. Promotions in the various branches, so far as practicable, are made consecutively from one rank to another. The company fills every position from among its own employes, provided there is anyone in the service competent to take the place.

In employing a motorman, after a personal investigation of his previous record, he rides with motormen and conductors having the best standing in the service until he is familiar with the special features of the lines of the company. He is then given the competitive examination, which consists of three parts: First, the applicant takes charge of the car with an inspector, who has to note the quality of his work for one trip over each line of the road; second, he answers a list of questions covering the various things connected with this department of railway service; finally, the applicant presents himself at the office of the general manager, where he is questioned in regard to all orders and instructions previously issued by the company, and his understanding of the conditions under which he will be expected to work.

A system of marks is employed, and if an employe's record falls below zero, he is discharged, and his advancement depends upon the rating which he secures by such marks. Each employe is invited to examine his own record or that of any other employe at any time. It has been found by experience that where employes work on such a competitive basis they invariably do their best.

Col. N. H. Heft, in a paper on the "Application of Electricity to Railroads now Operated by Steam Power," gave the results of the work done by the New Haven Company in this line. On the Nantasket Beach line the traffic increased enormously after electric traction had been adopted, the first

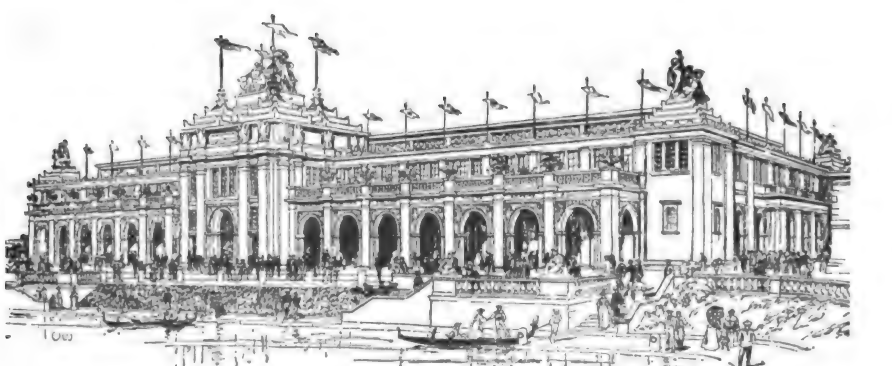
summer showing an increase of 92.6 per cent. and the second summer an increase of 45.1 per cent. over this, and in the past summer three times as many passengers were carried as in the last year of steam operation. On the Hartford-New Britain line, during the three summer months 400 per cent. more passengers were carried than through the corresponding months of last year before the adoption of electric traction. The experience with the overhead line on the Nantasket Beach was not satisfactory, and the third rail and ground return circuit are now employed with perfect satisfaction. It has been found that though water may accumulate 2 ins. or more over the ties, not the slightest difficulty is encountered in operating the road under these conditions; at the station nothing unusual has been noticed and the recording wattmeter has shown no abnormal output.

Some data as to the cost of power are given. At Stamford the cost of fuel is found to be 4.2 mills per KW-hour, while with the use of locomotive "sparks" the cost is reduced to 2.5 mills per KW-hour. At the Nantasket power house the cost of fuel with the use of coal averaged 5.6 mills per KW-hour, which, with the use of "sparks," was reduced to 2.8 mills per KW-hour. At Berlin the cost of fuel with the use of coal has been 12 mills per KW-hour, and with "sparks," 4 mills per KW-hour. In the latter case the plant has not been run as economically thus far as it will be when a greater load is put on the engines, and it would seem to be in the interest of economy to run it compound condensing.

In the discussion of his paper, Mr. Heft stated that "sparks" cost, delivered, 70 cents per ton, and coal $3 per ton. Replying to a question, he said that the third-rail construction costs about half that of overhead construction as formerly used on the Nantasket line.

TRANS-MISSISSIPPI EXPOSITION.

The accompanying illustration shows the machinery and electricity building which is to form one of a number of buildings to be erected at Omaha, Neb., for the Trans-Mississippi and International Exposition, which will be held from June to November, 1898.



ELECTRICITY BUILDING, TRANS-MISSISSIPPI EXPOSITION.

Prof. R. D. Owens is in charge of the electrical department, and Mr. Luther Steirenger has been retained as consulting electrical engineer. Mr. Steirenger is preparing plans for night illuminations, among which will be an electric garden showing the various hues and tints of the flowers by means of colored screens and powerful search-lights. Some fine effects will also be produced on the waters of the Missouri River, which flows by the exhibition grounds. A large number of applications for space from electrical firms have already been received, among these being the General Electric, Walker, Fort Wayne, Western Electric, Wagner Electric & Manufacturing, Crocker-Wheeler and Okonite Companies.

NOTES.

Words of Appreciation.—Believing that a technical journal depends for its standing entirely upon its intrinsic merit, and that complimentary expressions of opinion to the publisher or editor, have little or no weight in that connection, we usually do not print such communications, of which many hundreds are now on file. An exception, however, is made in favor of the following letter, as coming from an engineer of national reputation, and one who does not express an opinion lightly: "Your paper, which is always interesting to me, has been especially so during the past four or five months. The theoretical discussion on batteries is as good as a discussion at the A. I. E. E., and quite above the ordinary electrical journal correspondence. On the other hand, the discussion on fuses *vs.* magnetic cut-outs evens up the account, and justifies, as usual, your claim, that you publish a paper which is first of all practical and for the benefit of engineers and electricians engaged in practical work."

The Chicago Electrical Association.—The fall and winter program of the Chicago Electrical Association was inaugurated Oct. 1, by a paper on "Economy of Car Control," by Mr. J. R. Cravath. Mr. Harold Almert, on Oct. 15, read a paper on "The Evolution of the Isolated Electric Plant," and the following papers will be read at semi-monthly meetings extending to Jan. 21: "The Safe Current Capacity of Electrical Conductors" by Mr. C. H. Sewall; "Daily Mathematical Conveniences," by Mr. S. G. McMeen; "Heavy Electric Traction," by Mr. Cloyd Marshall; "Electricity in Shipbuilding," by Mr. C. C. Mattison; "Electrical Shop Transmission," by Mr. H. G. Dimmick; "The Art of Constructing Telephone Apparatus," by Mr. Henry P. Clausen. The officers of the association for the current year are Mr. S. G. McMeen, president; Mr. F. S. Hickok, vice-president; Mr. E. J. Jenness, treasurer; Mr. J. R. Cravath, secretary; Messrs. W. Clyde Jones, G. W. Knox and Kempster B. Miller, directors.

The Sprague Electric Company.—The recent incorporation of the Sprague Electric Company is an important event in the progress of the electrical industry. The new company will exploit the new Sprague electric railway system, which was described in our September issue; the Sprague electric elevator system; the Johnson-Lundell underground-conduit system, Lundell dynamos and motors and the interior-conduit system developed by the Interior Conduit Company. Mr. A. B. Chandler (president of the Postal Telegraph Company) is president and managing director of the new company; Mr. E. H. Johnson, first vice-president and general manager; and Mr. Frank J. Sprague, second vice-president and technical director. Among capitalists interested are J. Pierpont Morgan, John W. Mackay, John A. Roeblings' Sons, estate of T. Hood Wright, estate of Theodore Havemeyer and Zenas Crane, and Carl Schurz and John E. Searles are among the directors. With its great financial backing, with men of the calibre of Messrs. Chandler and Johnson to manage its bnsiness interests, and with a technical head of the resourceful ability of Mr. Sprague, the new company will undoubtedly become a great force in the electrical field.

An Abuse of Power.—The recent action of the Mayor of Terre Haute, Ind., in throwing the Terre Haute Electric Railway into the hands of a receiver, is one of the demagogic abuses of power that can only tend toward frightening capital from further investment in municipal improvements. The road in question having been burdened with large assessments for street paving, the State Legislature authorized an extension of the indebtedness thus incurred by the issue of bonds, and the City Council unanimously passed an ordinance accepting such bonds. The Mayor refused to sign the bonds, upon the ground that the act authorizing them was unconstitutional, notwithstanding the presentation of the highest legal opinion to the contrary, including one from ex-U. S. Attorney General Miller. On Oct. 19 a levy was made on the road at an early hour of the morning when the company could not get funds from the bank nor call on friends for assistance, and upon the affidavit of the Mayor as to city indebtedness the road was placed in the hands of the receiver, though part of the indebtedness is owned by the road and part was not due. No notice of the levy was given, and during the present year $5000 have been paid by the road on account of paving assessments. The entire animus against the road appears to lie with two city officials—the Mayor and Treasurer—the sentiment of the Council and citizens being distinctly in its favor. The case furnishes a sad commentatory on the demagogic and irresponsible character of municipal government with which some of our cities are afflicted. At the following meeting of the Council a resolution was adopted without a dissenting vote, referring in high terms to the management of the road by Mr. Russell B. Harrison, president, and Mr. M. F. Burke, general manager, and expressing the hope that the receiver should retain the services of these gentlemen and their staff.

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Testing of Insulators.

In these days of high-voltage power transmission the subject of line insulation has acquired a new importance, and particularly so that the insulation strain has approached a point destructive to the insulating material itself. Formerly it was merely a question of preventing leakage, but with the high voltages used to-day, the resistance to electrical stress must also be taken into consideration. The article on another page by Mr. N. Monroe Hopkins therefore performs a much-needed service in detailing the practical methods of testing insulators, to which are added several suggestions as to improved methods of test, both for insulators and cables. As all of the tests described are electrical, it will be well to recall the statement of Mr. J. G. White at the Niagara Electric Light Convention, that an indication of the electrical quality of insulators may be obtained by breaking samples, and immersing them in red ink; if any of the ink is absorbed into the material, the insulators are unfitted for high-potential work.

Fuses vs. Circuit Breakers.

On another page we print a fourth installment of the controversy on fuses and circuit breakers, in which a writer on each side of the question sturdily wields the cudgels for his particular device—we were about to say, hobby. It may here be pointed out that the issue in fact, if not in appearance, seems to be narrowed down to the relative advantages of the fuse and circuit breaker for other than electric-railway circuits, and for large currents. It has been admitted that the magnetic circuit breaker is best fitted for electric-railway circuits on which large but momentary fluctuations of currents may frequently occur under normal conditions of working. On the other hand, it is admitted that for small currents—Mr. Harrington places the limit at 10 amperes—the use of fusible cut-outs is not objectionable. Above all, it should be borne in mind that the type of fuse which is advocated in this controversy is not the plain wire, but the enclosed, fuse, which is claimed to eliminate the variable factors that have been the cause of justly bringing the first-mentioned type into such general disrepute. The controversy thus far has been a very instructive one, though perhaps at times developing rather more partisan spirit than warranted in a technical discussion. We hope, however, that it may continue, as even thus far it has formed the best practical contribution yet made the literature of fuses and circuit breakers.

Experimental Alternating-Current Apparatus.

On another page Prof. H. S. Carhart describes the construction of a universal alternator, from which a single alternating current or multiple alternating currents may be obtained at will, the latter either two- or three-phased. To the student or experimenter such a machine will be of much value, and its construction is so simple, requiring no special tools or dies, that it may be made at a very moderate cost. The rotary liquid converter of Prof. Carhart, described in our April issue, together with the present machine, form an admirable equipment for a laboratory, permitting as they do the illustration of almost every property of alternating currents, single and polyphased.

A make-shift for the above-mentioned very complete apparatus may be quite simply devised by anyone who possesses a pair of small direct-current motors, such as fan motors. To do this, tap screw holes in the ends of three equidistant commutator segments; secure a wooden ring concentric with the shaft, to three radial pieces of brass held by screws in the above-mentioned holes; on the surface of the wooden ring fix three rings of copper wire, which will serve as collector rings. If one of the motors is now run as usual from a direct-current circuit, a single alternating current may be taken from any two of the wire collector rings on the motor, or three alternating currents differing 120 degs. in phase—three-phased currents—may be taken with the three rings in action. By separately exciting the field of the second motor of the same type and similarly arranged, that motor may be run by the three-phased currents generated by the first machine. By also throwing in the brushes of the second machine, it will become a rotary converter, supplying a direct current from the brushes. If a small transformer is made by winding two coils of wire on a coil of soft-iron wire, the alternating current obtained may be stepped up or down in voltage, as desired. As to the frequency, the number of alternations being double the speed of the motor if bipolar, and there being two alternations to each period, the frequency will be 33 periods per second if the motor makes 2000 r. p. m.

The Primary of Induction Coils.

Some months ago we printed in these columns some remarks on the design of the primaries of induction coils, in regard to which there appears to exist a very general misconception. Owing to many inquiries since received, we will here take up the subject again, though at the risk of some repetition. The function of the primary is to introduce lines of force within the secondary, the number of such lines depending, with a given core, upon the ampere-turns. On the other hand, the E. M. F. of the secondary depends upon the rate at which these lines are withdrawn, being greater, the greater the rate. This rate in turn depends upon the rapidity with which the primary circuit is broken, which break does not occur when metallic contact at the contact-breaking points ceases, but only when the arc which follows is extinguished.

We thus see that so far as the break is concerned, the inductive E. M. F. at break which sets up the arc should be reduced to a minimum; that is, the inductance of the primary should be a minimum. The ideal primary would, then, be one with

a single turn, carrying a sufficiently large current to give the necessary ampere-turns. This also applies with respect to the make, for the less the inductance, the quicker will the lines of force be introduced, or, to express the same thing in other words, the quicker will the magnetism be built up; consequently, with a minimum of inductance, a maximum rate of make-and-break may be used, resulting in a maximum of secondary E. M. F.

The practical conclusion is that the primary of an induction coil should have the least number of turns possible, and this whether the coil is to be used on a battery or on an electric-lighting circuit. In the latter case, resistance should be introduced into the external circuit to cut down the current to the required amount, and this resistance should be non-inductive since, if inductive, it will introduce the same harmful inductive effects into circuit we have avoided in the construction of the primary. For this resistance incandescent lamps in parallel are best suited, their inductance being negligible on account of the smallness of the area of loop in comparison with the energy absorbed therein.

As to the resistance of the primary, this in any event will be so small in proportion to the equivalent resistance of the inductive E. M. F., as to practically not enter, and the size of wire may therefore be selected with reference to its current-carrying capacity alone. The advisability of using a condenser with an induction coil is not clear. At the make, it will without doubt assist the rapid building up of the magnetism, but with a coil of but few turns, the time-constant will be so small that there should be no practical necessity for such aid. At the break a surging current will be set up in the condenser and coil circuit, the action of which would appear to result in prolonging the discharge of magnetism. However this may be, if the turns are so few in number as to set up no considerable arcing at the contacts, a condenser will be unnecessary.

The Niagara Street Railway Convention.

The American Street Railway Association can boast of the largest attendance at its annual meetings of, perhaps, any scientific, professional or industrial body in the world at its corresponding gatherings. The registered attendance at Niagara of more than 1000 is almost double the number usually present at the convention of the National Electric Light Association, and is several times greater than that of any of the purely professional societies, even on unusual occasions. Not less remarkable is the industrial exhibition held during the convention under the auspices of the association, which is nothing less than an annual national exposition of the art represented, being complete in every detail relating to the latest advances. Were one required to make a report on the present state of the electric railway industry so far as relates to apparatus, appliances and material, he would only need to attend, with his note-book, such a convention as that held last month at Niagara. In attendance and opportunities to delegates to inspect the latest improvements in apparatus and material, the Niagara convention was thus a pronounced success. As much, we fear, however, cannot be said as concerns the presentation and discussion of papers. We hasten to add that this statement does not imply any weakness in the programme of papers or in their intrinsic value, for both in topic and treatment only praise can be offered. Neither does the criticism refer especially to the Niagara meeting, for its cause is due to a fixed policy of the association—that of not permitting the printing of papers in advance, nor allowing others than delegates to participate in discussions.

It is difficult to see what reasons can be advanced in favor of the prohibition against printing papers in advance of reading. The audience can follow a paper infinitely better with a printed copy before them, and if distributed in advance, the author need merely give a summary of the points inviting discussion, thus saving valuable time for this latter purpose. Experience has shown that discussion of any value cannot be expected under the present system for several reasons. The readers usually not being much of elocutionists, it is necessary to strain attention to catch the purport of a paper, thus distracting the mind; the memory not having the assistance of the eye, it is difficult to keep track of the argument or to correlate separated statements; above all, sufficient thought cannot be given to the points that suggest remarks in the mind of the hearer, and usually those with most authority to speak are the ones most chary in expressing opinions without a full and clear understanding of the case concerned. So far as we can recall, the American Street Railway Association is the only body of high standing that objects to the printing of papers in advance, that being the custom of the national professional and scientific societies, both in this country and abroad. It is undoubtedly for this reason that the discussions before the latter bodies are usually of a very high order, superior oftentimes in value to the papers that brought them forth —which was far from being true with respect to the discussions at Niagara. Until the papers are printed in advance and placed in the hands of delegates so as at least to be followed during the reading, we fear that the discussions at the street railway conventions will continue to be greatly inferior to those of similar bodies whose audiences do not labor under the disadvantage noted.

The policy of not permitting any but delegates to take part in discussions has at least the advantage that it prevents the time of the audience from being taken up by speakers having in view their own commercial interests rather than the bona-fide discussion of a paper. This danger, however, could be obviated almost entirely by a rule requiring consent in advance of a session from the president to other than delegates who desire to join in a discussion—which consent would most probably not be accorded without a proper showing. Still more important is the desirability of the presence of technical authorities to take part in discussions and answer interrogations from delegates on points brought forward. How much greater would the value of the sessions at Niagara have been to delegates if in the discussion of the important papers of Hewitt, Hoopes and Heft, such authorities as Steinmetz, Short, Scott, Bell and Lloyd had taken part. The most important technical points in electric traction at the present moment relate to rotary converters, boosters, storage batteries and the application of electricity on steam roads, and with those mentioned present, the discussion on these subjects would undoubtedly have been of the highest value and interest, not only to the convention, but to the profession at large; as it was, a few questions, some of them misconceived through difficulty in following the papers as read, together with the answers, were the sum total. Were invitations annually extended to technical authorities to attend the sessions and join in the discussion—the subject matter of papers to be read to suggest the names—no one will dispute, we believe, the assertion that the result would be to very greatly enhance the value of the convention to the delegates in attendance and give to its printed proceedings an interest far higher than they now possess. It may be said that the reading of papers on technical subjects and their discussion, is but incidental to the real object of the association, which relates more particularly to the management and operasion of street railways. Nevertheless, purely technical subjects have in recent years formed no small part of the programme of papers, and will probably continue to do so in the future. It would therefore seem to be the part of wisdom to profit by the experience of other bodies, and obtain a maximum of benefit by printing in advance at least papers dealing with technical subjects, and inviting authorities on such subjects to join in the discussion.

CONSTRUCTION OF AN ELECTRICAL TESTING SET—II.

SETTING UP THE BOX.

BY JAMES F. HOBART, M. E.

Before the instrument described can be assembled, some woodwork is necessary for spools and bobbins, and also for the box to contain the whole apparatus. For this purpose we can use pine, black walnut, oak or mahogany. The latter is good, but is apt to be heavy. The box here described was made of quartered oak, and although a little weighty, will stand a good deal of banging around—something surely met with in every-day practice.

The box can be made to order by a cabinet maker, of course, but so the entire instrument can be bought complete. I made my own box, and if the job is being done for the purpose of obtaining useful knowledge as well as an instrument, then make the box yourself, by all means.

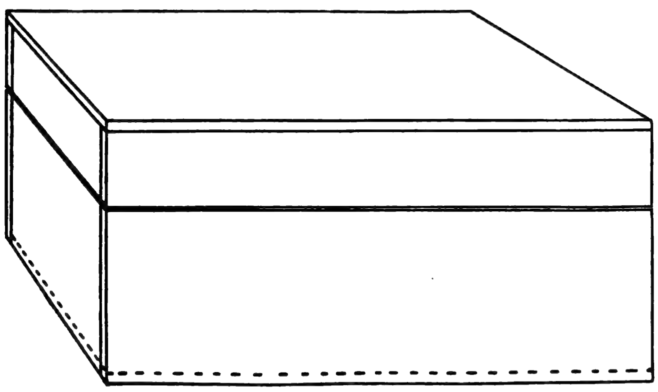


FIG. 43.—BOX COMPLETE.

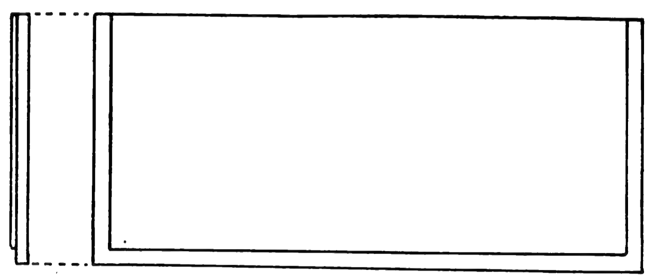


FIG. 44.—SIDE OF BOX.

Fig. 43 shows the box complete as far as the wood-work is concerned. It is made just large enough so that the hard-rubber base-board (Fig. 3) will fit inside. Stock ⅜ in. thick makes a box stout enough to stand the wear of use, and is not too heavy. The base-board is 12 ins. × 5½ ins. This box is made with the joints "halved together," to use the wood-worker's term, the ends being "let into" the sides ⅛ in., the top "let on" a similar amount, and the bottom also "let in" to both sides and ends. The box is 5¼ ins. deep inside.

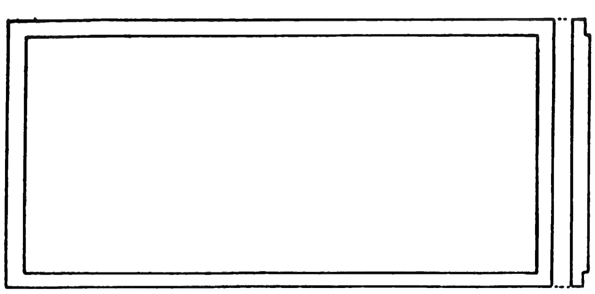


FIG. 45.—TOP OF BOX.

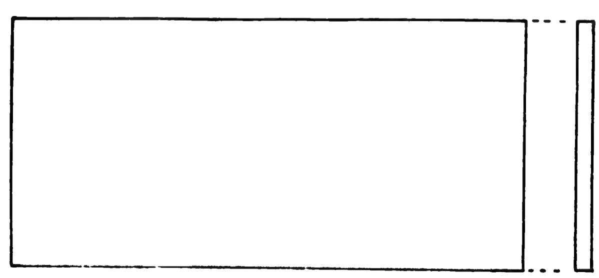


FIG. 46.—BOTTOM OF BOX.

The bottom must, then, be made ⅛ in. all around larger than the base-board, or ¼ in. longer and wider. This makes it 12¼ ins. × 5¾ ins. The sides will have a length of 12 ins. plus twice the thickness of the stock or 12¾ ins. The width of the sides will be the depth of the box, 5¼ ins. plus thickness of bottom, and of rebated top (⅜ in. and ⅛ in.), or 5¾ ins.

Be very careful not to make a mistake in the width of the sides and ends, or the length of the ends, or the size of the bottom and top. They are all different, owing to the rebating, or "letting in" of the ends and sides. Better to get out the bottom and top first, as they are not the same size inside of the rebating of the top, then make the sides and ends to fit. Additional width should be given the sides and ends, equal to the thickness of the saw used in cutting the box open to form the cover, as shown by the double lines near the top of Fig. 43.

Run the saw into a board, measure the width of kerf, and allow as much extra width over the 5¾ ins. above noted. If the sides and ends be made 5⅞ ins., a trifle of stock will be available for dressing off with a plane, where the top is cut off. It will be inferred from the above that the top and bottom, or the box and lid, are made in one piece and then sawn apart. This is the case, and much better work can be done than in trying to make each part separately.

If there is a circular saw handy, make the entire box with that tool. First cut all the pieces on the saw and then rebate them. The sizes are as follows:

Top,	1 piece,	12¾ins.×6¼ins.	
Ends,	2 "	5¾ " ×5⅞ "	wide
Sides,	2 "	12¾ " ×5⅞ "	
Bottom,	1 "	12¼ " ×5¾ "	white pine.

See that the saw is very sharp and set just enough to work well in the stock used. If there is an iron top to the saw bench the work can be done directly thereon; but if the top is of wood, and well worn at that, put a piece of thin board over the top of the saw table, and let the saw come up through the board. This will give a smooth, clean surface to work on.

Adjust the saw or table top so the saw will project through just ⅛ in. Set the fence, or guide, ⅜ in. from the saw, including the thickness thereof. Make all these adjustments and test them, using a waste piece of board therefor. Lay the top piece of the box right side up on the saw bench, and run all four edges (ends and sides) over the saw, keeping the piece well pressed down all the time, or the saw will leave some places not cut deep enough.

Next, take the sides, and run both ends and one side as above. Then stop the saw and bring it up through the top of the table ⅜ in., and set it ¼ in. from the fence—*not* including the thickness of the saw; run all the edges already cut over the saw again, standing the pieces up edgewise, and putting the side *not cut* against the fence. This action finishes the rebate by cutting out the thin strip, which will sometimes fly across the room with great velocity. Look out for these pieces, and do not stand in line with them.

There are several ways of fastening the box, nails, screws, glue etc., but the last was used in my box, and the sides and ends were clamped up as they came from the saw without any finishing whatever, and cold glue has held them to this day. If you are an expert "wood butcher" as well as an electrician, you may dovetail the box together, but the method of "halving" here described, will make a very good job and is done quickly.

As soon as the sides and ends are together, the top and bottom should be slipped into place to keep the box square. A very little fitting may be required to get the top and bottom in, but this will not be necessary if the sawing and measuring has been done exact. If the appliances of a cabinet shop are at hand, the top and bottom may be clamped in at the same time the rest of the box is put together, but there must be some means of clamping the pieces firmly until the glue has become hardened.

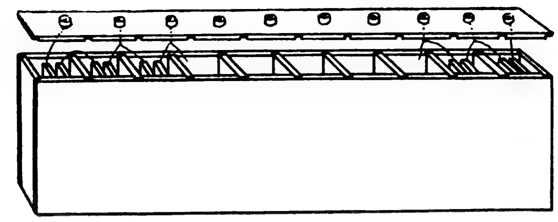
When dry (in 10 or 20 hours) take off the clamps, and smooth up the outside of the box. Go over it with a sharp smooth plane, and then scrape with a steel scraper, or pieces of glass, until smooth. A little sandpaper may then be used, but always rub lengthwise with the grain, never crosswise. If you do, scratches will show when the box is finished up.

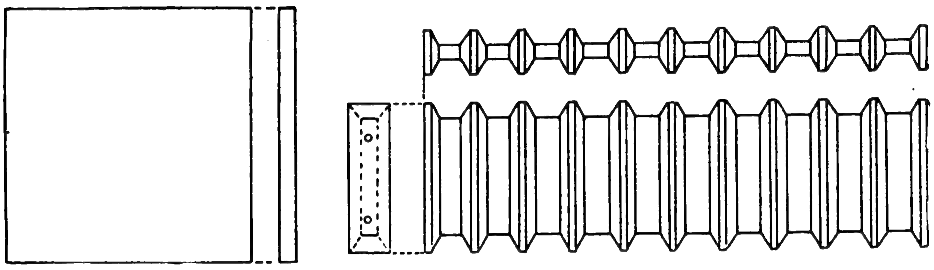
Next saw off the lid, and smooth up the joint. The hinges may be ornamental brass concerns, and fastened on to the outside of the box; this looks well, and is easier and

stronger than cutting the hinges on to the edges of the wooden side. Fig. 44 shows the side of the box, rebated on three sides. Fig. 45 is the top, rebated all around, on the inside. Fig. 46 is the bottom, cut square, no rebating, and Fig. 47 is an end, rebated on one side only.

As soon as the box is finished, it should be given a coat of "filler" to close the pores, then rubbed down with sandpaper and rotten stone, and given one coat of oil

file will soon cure that. After cutting all four sides of the block, pull out the nails and finish the other sides of the single strips, using the sides already cut as guides to the saw.



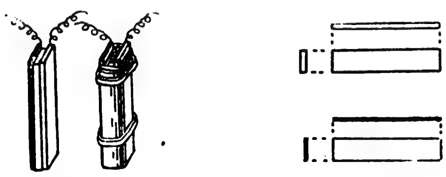


FIGS. 47, 48 AND 49.—END OF BOX, RESISTANCE SPOOL AND BATTERY BOX.

or varnish. After the brass and wire have been put in, the wood may be finished to suit; if it is done before, it will surely be scratched up. Get out four corner strips and glue them inside the box, reaching from the bottom to within ⅜ in. of the top. These corners should be about ½ in. on the square sides. They are for supporting the hard-rubber base-board.

I have described the manner in which my box was built. It required about one-half hour to saw out the pieces. It can be done by hand, of course, but it will take ten times as long, and be no better. As stated in the first paper, the drawings are so greatly reduced in size that dimension figures would only mar the appearance, and full sized working drawings will be furnished upon application to the author, at the cost of blue printing—hence the lack of dimensions in the illustrations.

Fig. 48 is a wooden core made for winding the unit, tens, hundreds and thousands resistance upon. It is made of dry pine, and is 6½ ins. long. Four will be required for a box. I made them on a band saw. Get out the pieces, well squared up, 1¾ ins. × ½ in. and fasten them together with a couple of small nails. Leave the ends long enough for this purpose, and cut off afterwards. Lay out the shape on two sides of the nailed-up block, or paste the blue print (an extra one of Fig. 48 will be furnished for this pur-



FIGS. 55, 56, 57 AND 58.—BATTERY ELEMENTS.

pose) right on the block; then put it under the saw.

Some very clean, straight-grained wood must be selected for these pieces, as only the angles are to be sawn in, the bottoms of the notches being split out by putting a knife or chisel in the saw-kerf. This leaves the bottom of each notch very rough, but a

The holes in the end of this block are for screws that go through the brass strips (Fig. 41), which form legs or supports for the wooden strips. The brasses are to be screwed to the rubber base board (the under side) as will be shown in the next paper.

One more piece of saw-work remains to be done, and that is, to make the hard-rubber battery box (Fig. 49). This just fits into the lid of the box, as shown in Fig. 1, and is, therefore, 12 ins. long, 3 ins. wide and 1 in. deep, outside measurements. The box is made of hard rubber, ⅛ in. thick and put together in the same manner as the outer box.

Fig. 50 shows the side of the battery box, and the manner of cutting the grooves for the ends, bottom and partitions. This is all done on the circular saw in about the same manner that the wooden box was made. It will be a job to keep the saw sharp, but don't try to cut hard rubber with a dull saw, as you will spoil it sure. The rubber can also be worked by hand, with saw and chisel.

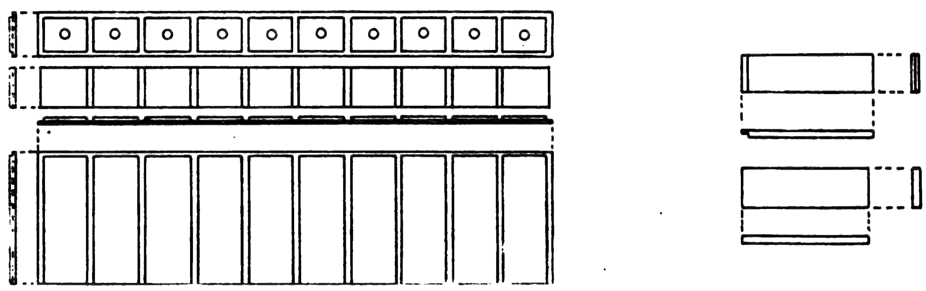
I constructed this battery box, and will describe it, but it is better to use a wooden block of the same dimensions, bored with ten holes in which small bottles are fitted, to serve as cells. It is cheaper, and better in every way, except for the name of having a "hard-rubber battery box." Fig. 50 is the side, two of which will be needed. Fig. 51 is the bottom, and Fig. 52, the top. These four pieces should be grooved for the partitions before they are cut apart. It is easier, and secures a much better fit. Figs. 53 and 54 are the ends and partitions, respectively. The manner of making them will be suggested from similar work on the wooden box.

The battery box may be cemented with "hard-rubber cement," to be purchased of rubber workers. I tried asphaltum, but it didn't prove satisfactory. Neither did the ordinary rubber cement made with bi-sulphide of carbon. The battery elements are shown by Figs. 55 and 56. They are of silver and zinc, respectively, the silver being very thin as shown. This is the common chloride of silver cell, and its make-up may be found described in the usual text books. I put bits of blotting paper between the strips of metal, as shown by Fig. 57, then wound more blotting paper around both, and snapped on a couple of small rubber bands, as in Fig. 58. The blotting paper was saturated with the solution, and before putting the elements in the cells, all the solution the paper would hold was given it. One of the little brass contacts (Fig. 31) will be needed for each cell of battery. It is to be put through each hole in the battery case top, and connected by wire with the elements in each cell, as indicated in Fig. 49. After the battery has been put together, the top may be fastened on with half a dozen ¼-in., No. 1, round-head wood screws.

All the mechanism of the box may now be put together, as shown in the plan (Fig. 2) and the strips and circular connections must be screwed home very solid. If there is the least give to the stems in any of the holes, the box will not work satisfactorily, because of the "dodging" of the pieces when putting in the plugs. If any of the holes are found to be too big, or not to fit, requiring cutting or filing sidewise, fill such cavities solid full of glue before screwing home the nuts. A socket wrench is necessary for this. Drill a hole in a steel rod, and have the hole long enough to take the shank (Fig. 7). Fit the end of the hole to take the nut (Fig. 9), square the outer end of the rod to fit a small tap-wrench, and a good cheap socket wrench is secured, which will do the business in good shape.

Put a plug in the hole when screwing up each of the contact pieces (Fig. 7) so the hole will come fair and stay there. After screwing up all the nuts, run a small taper reamer into all the plug holes. This being done, any plug will fit all the holes, and any hole will receive any plug. Some "dowell rod" about ⅛ in., or 3/16 in. in diameter must be secured for winding the ratio coils upon, as will be illustrated in the next paper. This rod may be obtained of any carriage builder or hardware dealer. Ten pieces 3 ins. long, each, will be required.

The box is now ready for winding, and the calculation and execution of that important part of the work will be discussed in the next (and last) installment of this article.



FIGS. 50, 51, 52, 53 AND 54.—DETAILS OF BATTERY BOX.

AMERICAN TELEPHONE PRACTICE.

BY KEMPSTER B. MILLER.

LISTENING AND RINGING APPARATUS FOR SWITCH-BOARDS.

In order to accomplish the changes of circuit by which the operator is enabled to connect her telephone with the line of any subscriber, and to send calling current to actuate the bells at any subscriber's station, many forms of circuit-changing switches have been devised. One of these, shown in Fig. 1 and known as the O'Connell key, has been in long and successful use in this country. Six different contact springs are so mounted and formed as to be acted upon by a wedge, b, of insulating material adapted to slide vertically among them. This wedge is mounted upon a rod, carrying at its upper end a button, by which it may be raised or lowered by the operator. The two springs, b^3, form the terminals of the two strands of the flexible cord leading respectively to the tip and sleeve of the calling plug. These springs are provided with rollers, b^7, in order to reduce friction when acted upon by the wedge, b. The springs b^4, form respectively the terminals for the strands of the cord leading to the tip and sleeve of the answering plug. The two springs, b^2, are connected each to one terminal of the operator's set while the pins, b^5, are connected each to one terminal of the calling generator. The normal position of this apparatus is when the wedge is raised to its highest position. In this position the springs, b^2, rest against the smallest portion, b^1, of the wedge, b, and are not in engagement with the springs, b^3. The springs, b^3, however, rest against the springs, b^4, thus making complete the connection from the tip and sleeve of the answering plug to the tip and sleeve, respectively, of the calling plug. In this position two subscribers may converse without being heard by the operator.

When the button is depressed one notch the springs, b^2, ride upon the second portion of the wedge, b, thus forcing them into engagement with the springs b^3, without causing these latter to break contact with the springs, b^4. In this position the circuit between the two plugs is not broken, but the operator's telephone set is connected across the two strands of the cord, thus allowing the operator to listen in and to communicate with either of the two subscribers who are talking. In its third position, which is that shown in Fig. 2, the springs, b^3, break contact with both springs, b^2 and b^4, and come into contact with the pins, b^5, which are connected with the terminals of the generator. This sends calling current to the called subscriber without affecting in any manner the circuits leading to the calling subscriber. When the button is depressed to its utmost extent the springs, b^3, are pressed outwardly as is shown in Fig. 3, until they not only make contact with pins, b^5, but also with pins, b^6. These pins, b^6, are each connected to pins, b^8, against which the springs, b^4, are now resting. This completes a circuit from the generator terminal, b^5, through the springs, b^3, to the pins, b^6, thence to the pins, b^8, and thence through the springs, b^4, to the sleeve and tip of the answering plug and to the line of the calling subscriber. Thus in this final position of the key, calling current is sent not only to the subscriber to be called, but also to the one who originated the call. Of course, this is necessary only, when for some reason the calling subscriber has left his instrument.

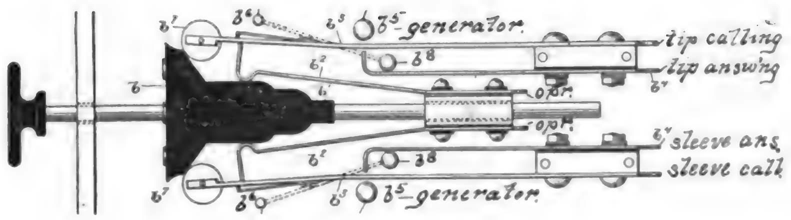
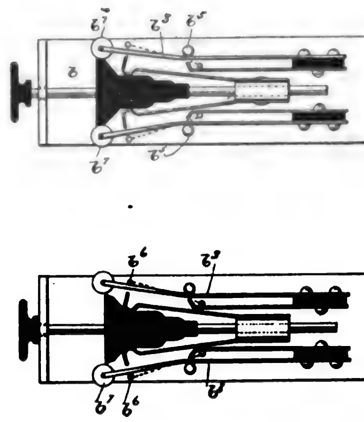


FIG. 1.—O'CONNELL KEY.


FIGS. 2 AND 3.—O'CONNELL KEY.

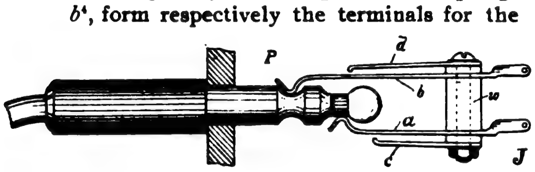


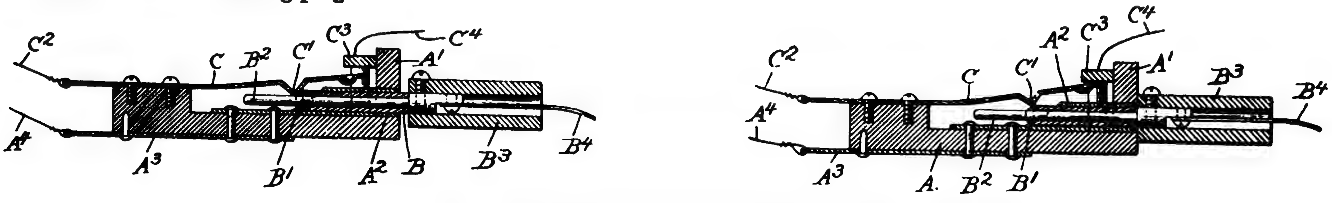
FIG. 4.—MILLER JACK AND PLUG.

In later and better keys, arrangement is made whereby either the calling or the called subscriber may be called without disturbing the other.

To facilitate the manipulation of switchboards it is, of course, desirable to make the number of motions necessary to effect a connection as few as possible. If, therefore, some act which must necessarily be performed by the operator in inserting a plug in or withdrawing it from a jack can be made use of to bring about some of the other changes of circuit, a decided advantage is gained. In Fig. 4 a device designed by the writer is shown. The line springs of a jack are represented by a and b; c and d are two springs arranged adjacent to the line springs and forming terminals of the operator's telephone set. The plugs are formed with alternate depressions and enlargements which are so spaced that when the plug is partially inserted into a jack the two line springs ride upon the two enlargements, thus pressing the line springs into engagement with the operator's terminals, c d. This places the operator into communicative relation with subscriber. After the operator has learned the connections desir d, she inserts the plug fully into the jack, thus allowing the two line springs to fall into the recesses of the plug. This maintains the connection between the line and the conductors of the plug, but breaks the connection between the operator's telephone and the line. The apparatus is then in the position shown in Fig. 4. If at any time the operator wishes to listen in without breaking the connection between two subscribers, she may do so by partially withdrawing the plug. If she finds that they are through talking, the movement is continued and the plug replaced in its seat. Where this device is used an ordinary ringing key is required to connect the generator across the terminals of the calling plug.

In Figs. 5 and 6 is shown a device in common use, designed by Mr. W. O. Meissner, which accomplishes the connection of the calling generator with the line of the subscriber called for by inserting the plug to its utmost extent into the jack.

The illustrations show a jack and plug for common return or grounded lines. In Fig. 5 the plug is shown partially inserted into the jack, in which position the line spring, C, makes contact at the point, C^1, with the conductor, B^2, of the plug, thus completing the connection between the line, C^2, and the strand, B^4, of the cord. In this, position the circuit is continuous between two connected subscribers or between the operator and one subscriber, as the case may be. When it is desired to ring out on the line, C^2, the plug is pressed to its fullest extent into the jack, as shown in Fig. 6. In this position the spring, C, rides upon the insulated sleeve, B^1, of the plug, thus breaking connection between the spring and the contact, B^2, and at the same time pressing the tip of the spring into contact with the plug, C^3, which is con-


FIGS. 5 AND 6.—MEISSNER JACK AND PLUG.

nected by wire, C^1, to one terminal of the generator. Current from the generator thus flows to line until the plug is released, at which time it is forced outward by the action of the spring and again resumes the position shown in Fig 5. Where this device is used, listening in by the operator is accomplished by an ordinary listening key.

In Fig. 7 is shown another device designed by the writer for listening in. *P* is the calling plug of any pair, and is shown in its normal socket on the key table. By tilting it in its socket until it assumes the position shown in the dotted lines, the spring, *S*, is forced from its normal position, and thus presses the springs, *q* and *r*, into engagement with terminals q^1, and r^1. As is shown by the diagram, this act connects the operator's

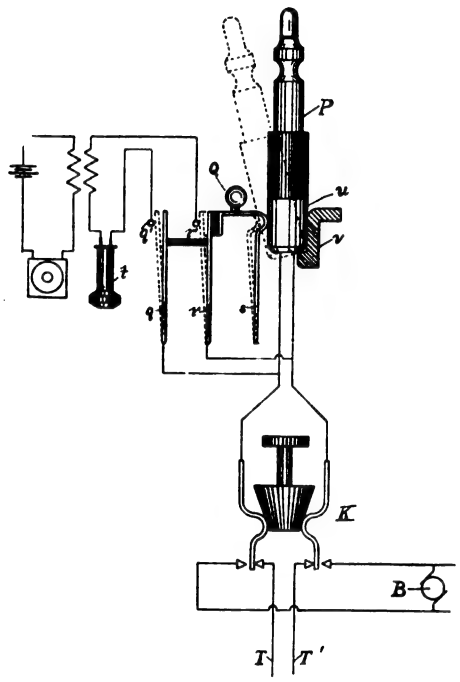


FIG. 7.—LISTENING-IN PLUG.

telephone set across the two strands of the cord circuit, TT^1.

The knob, *Q*, upon the spring, *S*, may be used to connect the operator's telephone across the cord circuit, in case it is desirable to listen in after the plug, *P*, has been removed from its socket. Calling is done by pressing the key, *K*. This affords a very rapid means for connecting the operator's telephone into circuit with any line, for after having inserted an answering plug into the jack of a calling subscriber, she can, by part of the movement which withdraws the calling plug, *P*, from its socket, connect her telephone with the calling subscriber's line. A continuation of this movement completes the connection with the called subscriber, and at the same time cuts the operator's telephone out of circuit.

Comparative Efficiency of Illuminants.

Of the total energy supplied, a candle consumes 86 watts per candle; oil lamp, 57 watts; butterfly gas burner, 93 watts; incandescent lamp, 3.5 watts; arc lamp, .8 watt. Thus, if gas is used in a gas engine having an efficiency of 20 per cent., it will produce about five times more light from incandescent lamps than if burned direct in jets.

THE CONNECTING OF DYNAMOS FOR SIMULTANEOUS OPERATION.

Dynamos, alternators and transformers often require to be connected so as to feed a common circuit, and unless special precautions are taken they will often interfere with each other's operation. The object of this article is to review the various methods for connecting dynamo-electric machines for simultaneous operation, and although all the information given here is to be found in a somewhat scattered condition in numerous other places, yet it is believed that a concise and complete compilation of the methods into a single article may be acceptable.

Machines may be connected in two principal ways, series and multiple, and combinations of these methods are sometimes used. In a system of series-connected machines, the current is limited to the capacity of the smallest machine, and the voltage is the algebraical sum of their pressures. Connected in multiple, the voltage is that of a single machine and the permissible current is the sum of their current capacities. For multiple-connection machines must have the same voltage, and for series connection they must have the same current capacity. In the latter case this condition is necessarily imposed only when it is intended to work each machine at its full output. Dynamos of different current capacities can be, and have been, connected in series for experimental purposes, but the maximum current that the system could supply is that of the smallest current capacity of its components. In the case of parallel operation, equality of voltage is indispensable. The machines must not only be of equal voltage, but the voltage must be *maintained* equal at all times, and this latter requirement often demands special connections.

The various machines used in practice are comprised in the following list: Simple shunt dynamos, series dynamos, compound dynamos, alternators separately excited, and compound, rotary and static transformers. Each of these machines can be connected in series or multiple with others of its kind.

The shunt machine in multiple is the most common case and nothing more than simple multiple connection is necessary, the like poles being connected together. The connection must be made when the voltages of the machines are equal, and they can easily be adjusted by means of their rheostats to divide the load equally between them. It may be noted that if one machine is operating connected to load, and another is brought to its terminal voltage and connected in multiple with it, that the second machine will take less than its due proportion of the load, because when it commences to take load, the loss of pressure in the armature causes its terminal voltage to fall. The rheostat must then be adjusted so that the machine takes its proper current. For this reason it is customary to bring the voltage of a shunt machine a few per cent. high before throwing it in multiple with others. Shunt machines in multiple require constant attention as the load varies, for unless they are surprisingly alike in characteristic curves and in driving power, they will not take load in proportion to their capacities at all times, no matter how carefully the rheostats have been adjusted when connection was made.

To shut down a shunt machine working in parallel with others, reduce its current to 10 per cent of full load with the rheostat, and immediately disconnect it from the mains.

Shunt machines in series will operate satisfactorily provided the directions given below are observed. The amount of pressure that each contributes to the voltage of the system can be varied from practically zero to a maximum with its rheostat. A modification of this combination is employed

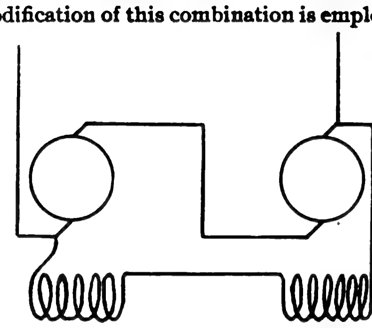


FIG. 1.—SHUNT MACHINES IN SERIES.

in the well known three-wire system, in which a third or neutral wire is led away from the common connection of the two machines. As this arrangement is made so that lamps may be connected on either side of the neutral, great care is necessary to keep the voltage on either side of the neutral the same. In the three-wire system the pair of dynamos are almost invariably of like capacity. Where a second set of machines is connected in multiple on a three-wire system, the machines on each side must be watched with a view to keeping their loads proportionate to their capacity, in the same way as described in the paragraph on shunt dynamos in multiple.

Shunt dynamos will operate in series by simple connection, but the rheostat of each machine must be watched to keep each machine supplying its share of the voltage. If the machines are exactly alike,

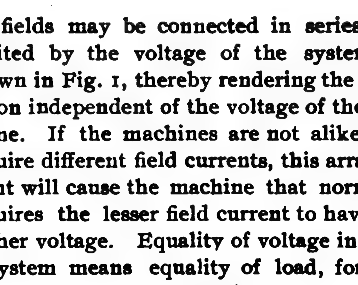


FIG. 2.—SHUNT MACHINES IN SERIES.

the fields may be connected in series and excited by the voltage of the system as shown in Fig. 1, thereby rendering the excitation independent of the voltage of the machine. If the machines are not alike and require different field currents, this arrangement will cause the machine that normally requires the lesser field current to have the higher voltage. Equality of voltage in such a system means equality of load, for the main currents are necessarily equal.

Equality of voltage may be secured if there be but two machines in a system by causing one to excite the other's field. By this means any attempt of one machine to generate more than its share of the voltage will

strengthen the field and thereby raise the voltage of the other. This arrangement is shown in Fig. 2.

Another way is to arrange that all the shunt coils be fed by one armature (see Fig. 3). This has the advantage of enabling any but the exciting machine to be shut down or started up without interfering with the operation of the system, and if it is necessary to shut down the exciting armature, the excitation can be transferred, field by field, to another dynamo; for if the system is presently to be deprived of the voltage of one machine, it is obvious that a momentary loss of another, while the change of its field connections is being made, will not be an interference.

To start such a system, start the exciting armature and bring it up to voltage and then connect the other fields in multiple with it, thus bringing all the other armatures up to voltage. The load may then be connected on. The voltage of the entire system will be controlled by the rheostat of the exciting machine.

When it is desired to shut down, reduce the current of the system to zero by means of this rheostat; or if the system is in multiple with another reduce to 10 per cent. of full load, and open the main current in precisely the same way that a single machine would be shut down. To shut down a single machine on this system, reduce its field curent to zero and break its field circuit. Then (see Fig. 4), short-circuit it at *A*, and break the connections at *D D*. To connect in again, connect *D D*, open *A*, excite the field and bring the machine up to speed.

Series dynamos are not operated in parallel to any great extent, and special connections must be made to prevent their interfering with each other. If connected in simple multiple, one of them will almost instantly get the upper hand and drive the other as a motor. As the rotation of a series dynamo reverses when driven as a motor, this action is very damaging, both mechanically and electrically. A series dynamo connected in multiple with others is in a condition of unstable equilibrium. If its speed should momentarily drop a trifle so that the current it was supplying diminished in the slightest degree, the field strength would fall off and reduce the current still further. It is a cumulative process and the machine instantly motors. There are two methods of connecting that will prevent this. The first is applicable to two machines only, but is the better of the two. It is simply to cause one machine to excite the field of the other, as shown in Fig. 5. Any attempt of one machine to gain ascendency over its mate will result in strengthening the field of the machine it is trying to overcome, and thus motoring is rendered impossible.

Where several machines are to be operated in multiple, they are connected together at their brushes as well as at their terminals, which extra connection is known as the equalizer connection. The arrangement of such a system is shown in Fig. 6, and its action is as follows: If one of the machines begins to lose pressure for any reason, current flows to it from the other machines through the equalizer and out through the series coil, thus building up the lagging machine and cutting down to its own exciting current. In other words, the total current of the system is proportionally divided among the series coils by the device of connecting them in parallel, and the load each machine will carry is practically proportional to its excitation.

When starting up a series machine to run in multiple with several others that are already operating, the connections, *A* and *B*, should be made first, and after a moment *C* may be made also, and the load will properly divide. The equalizer connections should be of the heaviest copper. Theoretically their resistance should be zero for perfect regulation.

Series machines will operate in series without any difficulty, and this is often practiced in the case of arc machines. The only care is to properly connect then. Some arc machines are shut down by the device of short-circuiting their armature, and when the machines are run singly this is very satisfactory, for, as will be readily seen, the short-circuiting of the armature cuts all current out of the field also, and the machine is almost instantly deprived of electrical energy. If this device is used on arc machines connected in series, it will result in disaster. Short-circuiting the armature does not in such a case cut the current out of the field, for that will be maintained by the other machines, and unless the short-circuited armature is a powerful inherent regulator, the current that will be generated in it will be so large as to quickly burn it out. In a system of series machines, to cut out one of them, short-circuit first the field and then the armature. These operations should follow one another promptly, for the armature deprived of E. M. F. becomes a sort of make-and-break for the current from the other machine, and if this is allowed to continue, the commutator will be needlessly burned. Especially is this true of arc machines of the open-coil type. In cutting the machine into circuit the reverse order should be observed, first the armature and then the field. Great care should be taken not to cut the field in first, no matter whether the armature is on short or open circuit. If the armature is on short circuit in such a case, the current it will generate will be excessive, as before stated, and if it is on open circuit, the armature voltage due to the separately excited field, with no armature reaction to quell it, will, if it is an arc machine, be so enormously high that it will certainly break down the insulation. This is a great objection to a separately excited arc machine, for open circuit while running is certain to destroy its armature insulation.

Compound dynamos may be operated in parallel by the device of equalizer connections. Where the series coils are very small in magnetizing power, the equalizer has been omitted, but it is not advisable to do this. Compound machines may be run in series by observing the precautions as described under shunt machines in series.

To cut out a compound machine in series with a system, the shunt coils of which are all excited by a single machine, destroy first its shunt excitation by the rheostat and opening circuiting; second, its series excitation by short-circuiting; and third, short-circuit the machine and cut it out, as previously described. To cut it in, employ a reverse order: First, the armature; second, the series field; third, the shunt field.

Alternators may be connected in multiple and will operate very well in this way, the load being strictly proportional to the power supplied to each machine. The terminals of an alternator are alternately + and —, and it is necessary to adjust the alternations of the machines to be connected together so that their terminals shall be + and — at the same time, before actually making connection. From this it will be easily seen that alternators of different frequencies cannot be connected together.

To determine when two alternators are in step, the device shown in Fig. 7 is most often employed. The voltage of the machines themselves is reduced by transformers, and obviously when the transformers are in step, the machines will be so also.

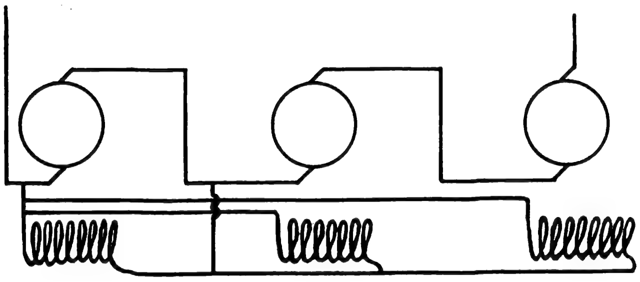


FIG. 3.—SHUNT MACHINES IN SERIES.

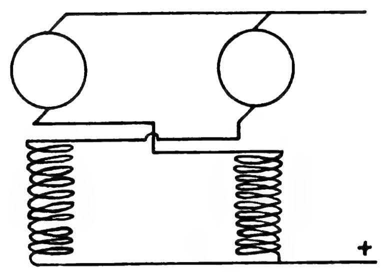


FIG. 5.—SERIES MACHINES IN PARALLEL.

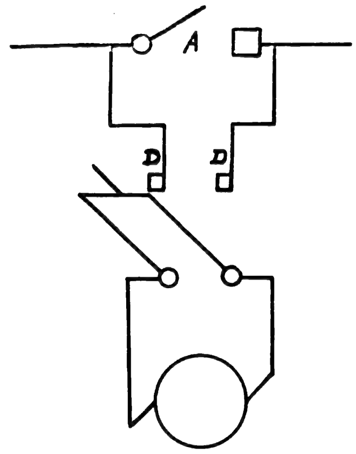


FIG. 4.—METHOD OF DISCONNECTING FROM SERIES CIRCUIT.

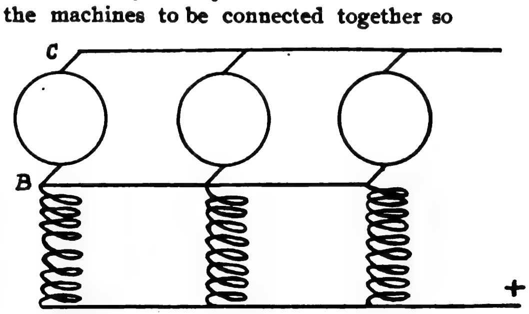


FIG. 6.—SERIES MACHINES IN PARALLEL.

If we connect the two transformers together, it is obvious that when A has the same polarity as A', and B has the same polarity as B', no current will be exchanged between the transformers. At such time the machines are ready to be connected together.

To reduce the current that the transformers are liable to generate and also to detect when it disappears, a lamp, the voltage of which is equal to the sum of the voltages of the transformers, is introduced in the circuit as shown. When the machines are started the light will begin to fluctuate from full brilliancy to extinction, and at times when the lamp is dark the machines may safely be connected in multiple, upon which the light will cease to flicker, showing that the machines retain their step.

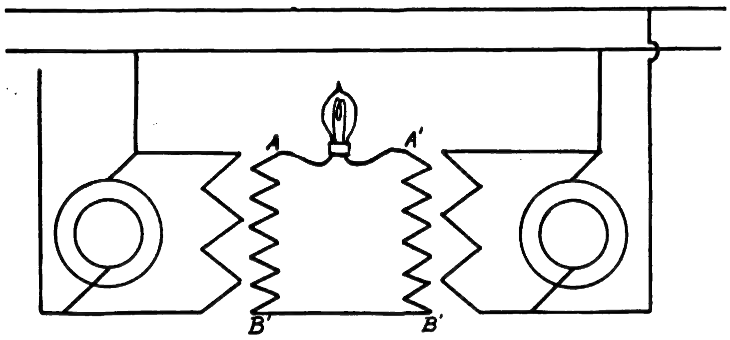


FIG. I.—SYNCHRONIZING DEVICE FOR ALTERNATORS.

The load of the machines is dependent on the power of the engines more than anything else. The machines will operate at the same speed whatever happens, and if the engines are not so adjusted, the lagging machine will be relieved of its load so that it can maintain speed, or it will even be dragged along as a motor. Thus, if one machine tends to monopolize the load in spite of rheostat adjustment, adjust the engine governor for lower speed at a convenient opportunity. If the machines are driven from the same engine, look for belt slip or inexact ratio of the driving pulleys. If the latter exists, correct it by changing the pulleys or gluing paper to the face of one of them, as may be most convenient. Alternators are cut out of multiple circuit in the same way as direct-current machines.

Alternators will not keep in step when connected in series, and for this purpose it is necessary to connect them rigidly to the same shaft. This is seldom done, for double voltage can be too easily obtained by the use of transformers.

Static transformers can be connected either in series or multiple on their secondary circuits and will operate perfectly well, provided their primaries are excited by the same circuit. The only care is to connect similar terminals together for parallel, and dissimilar ones together, for series operation. Sometimes it is desired to obtain very high voltages for experimental work by connecting the secondaries of a large number of transforms together in series. In doing this it must be remembered that the total voltage of the system must not exceed the dielectric strength of a single transformer, for the positive and negative ends of the system are brought within two thicknesses of the insulation separating primary from secondary by means of the common primaries.

Rotary transformers can be connected in multiple on the direct-current side in the same way as shunt or compound dynamos. To connect them in series they must be each fed from separate static transformers or separate alternators, for any attempt to connect them in series when fed from the same alternate-current mains would result in short-circuiting the latter.

STRAY-POWER METHOD OF DYNAMO TESTING.

BY WM. LINCOLN SMITH.

Toward the end of the article upon the stray-power method of dynamo testing in the October number I notice several slips, which uncorrected will vitiate decidedly the result of any test in which the method is used. These are in the second and third paragraphs of page 402. The total loss minus the total C^2R of the system is, of course, the stray power of both machines, not twice this quantity, and must not be divided half and half. The armature voltage is not the same for each machine, but in that machine acting as dynamo it is V (at brushes) $+ C_A R_A$, and in the motor V (at brushes) $- C_A R_A$; as the speed is the same the stray power varies nearly with the field. Armature voltage is the measure of this, and hence the total stray power should be divided proportionately to this quantity.

Further on we read some statements in regard to series-motor testing on constant-potential circuits. This test can be very easily, simply and correctly made by the method under consideration, but, contrary to the article, the motor fields *must* be included in the test, else the motor is not being tested under proper conditions. The diagram is given above.

The system is connected up with a flexible coupling, and the motor armature, field and starting resistance, R, all in series, and started as usual from the supply mains, when up to speed, R all cut out, vary the dynamo voltage by means of its separately excited field till $V_D = V_{supply}$; then close S. Increasing the total voltage of the dynamo will now increase its output, and *vice versa*. Thus the motor can be brought to the proper conditions of load and speed. Now the power coming in from the supply system measures the total loss. Take out the C^2R's of dynamo armature, motor armature and motor field, and the result is the total stray power *at this particular speed*. If this is not exactly right, the stray power should be corrected for speed. As to the armature voltages, they are $V_{supply} + C_A R_R$ (dynamo) for the dynamo, and $V_{supply} - C_A R_{(A+F)}$ (mot.) for the motor, and the stray power for the motor, which is the machine under test, is

$$\frac{\text{St. Pr.} \times (V_{\overline{\text{supply}}}\, C_A R_{A+F}\ (\text{motor})}{V_{\text{supply}} + C_A R_A\ (\text{dy.}) + V_{\overline{\text{supply}}}\, C_A R_{A+F}\ (\text{mo.})}$$

which is very decidedly different in value from the result obtained by simple halving.

[I think that if Mr. Smith reads the article with more care that he will note on the third column of page 401 that the stray power is assumed proportional to the speed and armature voltage; but the context that he criticises certainly conveys the impression to the casual reader that the combined stray-power losses should be halved, and it should have been more carefully written. In that respect I am indebted to him. Although it is most convenient it is in nowise necessary to have the series field of a motor tested by the method in question, included in the test. Provided that the field and armature current are kept the same strength

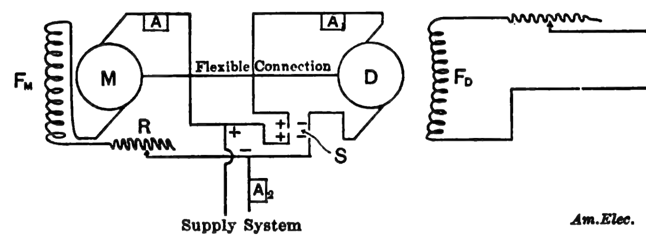


DIAGRAM OF MOTOR TEST.

as noted in the article, the conditions of practice are exactly attained and the C^2R losses of the field can be omitted from the calculation of the stray power. The armature voltage can be calculated from the brush voltage and the CR drop of the armature. There would probably arise many cases where the difficulty of keeping the field and armature currents equal would be too great to admit of excluding the field from the test. As the next article on the subject shows, Mr. Smith has anticipated me a little, but his criticism suggests that the installments of the series should be more complete in themselves. The insertion of the word "twice" at the bottom of the second paragraph, page 402, is obviously a clerical or typographical error.—Writer of article.]

TESTING DYNAMOS.

THE STRAY-POWER METHOD.

Railway motors are frequently tested in pairs and it is most convenient to use the stray-power adaptation of the Hopkinson method to test them. In the closing of the last chapter it was pointed out that they might be tested by separately exciting their fields.

The motor being the machine under test, the field current should be exactly the same strength as the armature current, for that is true in practice. If this is difficult to obtain there is no objection to including the motor fields in the test, but if this is done their C^2R loss must be measured and allowed for in computing the stray power. The dynamo fields must, however, be separately excited on account of the instability of the series dynamo on constant potential before mentioned. The resistence of series fields is so low that this requires a low voltage or an immense rheostat to keep the current within

proper limits. A storage battery is appropriate, but not always convenient. This may be regarded as one of the disadvantages of the method.

Fig. 1 shows the connections of another method of testing a pair of series motors for the stray-power losses of one of them. The machines are mechanically coupled and connected in series, and current is fed in from an outside source in series with the system. By shunting the field of one of the machines a certain amount, it becomes the motor to the exclusion of the other. The dynamo is connected with its positive terminal to the negative of the source of supply, and the two together supply the motor with current, which in turn drives the dynamo. The input from the outside source, less all the heating losses of the system, is the stray power of two machines, and should be divided between them in proportion to the armature voltages. A disadvantage of this system is that the motor, which is usually the machine under test, is operating with a shunted field and is therefore not under commercial conditions, but the inaccuracy is not very serious at full load when the fields are highly saturated. The method has the advantage that a source of supply of much less voltage than that of either of the machines can be used, provided that the full load current can be drawn from it.

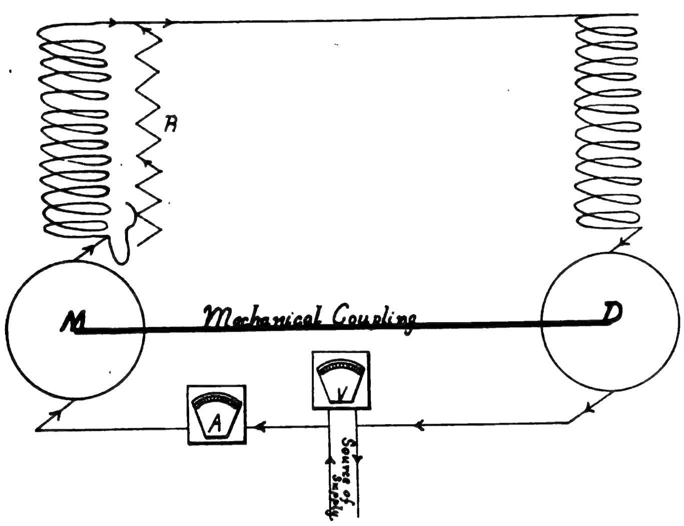


FIG. 1.—CONNECTIONS FOR MOTOR TESTING.

Thus it would be possible to test two 500-volt motors with the current from a 110-volt lighting system. A rheostat or water resistance would have to be used to regulate the current supplied to the system, and in such a case it must be remembered that the watts supplied are equal to the difference of the watts taken from the mains and that consumed in the rheostat. If the voltmeter is connected as shown in the diagram, this need not be considered, as the watts consumed in any rheostat connected in series with the source of supply are not measured.

Some of the general methods of testing for stray power have been described, and as the reader has doubtless noted, they consist primarily of determining the stray power of the machine at as nearly the commercial conditions as can be attained, and then certain indicated corrections are applied. The method of applying these corrections will now be explained in detail.

The stray power is assumed to be directly proportional to the speed and to the armature voltage. Thus, if it were not possible to obtain exactly the commercial speed, but, instead a speed differing by a few revolutions, the stray power would be corrected by multiplying it by $\frac{S}{s}$, the commercial speed being S. Similarly, if an armature voltage, v, obtained during the test, the commercial voltage being V, the stray power would have to be corrected by multiplying it by $\frac{V}{v}$ before incorporating it into the efficiency calculation.

The armature voltage of a machine is not the voltage that is measured across the brushes, but is that voltage plus or minus the armature drop, according as the machine is a dynamo or a motor.

To illustrate, suppose that a 110 volt shunt dynamo had an armature resistance of .04 ohms, and at full load carried 90 amperes at a speed of 1400 r. p. m. Under a stray power test it was run as a motor and a speed of 1390 revolutions, and an armature current of 3 amperes resulted from adjusting the terminal voltage to the same figure—110.

The stray power would then figure out to be 329.64 watts. We would have to correct this; first, by multiplying by $\frac{1400}{1390}$, and second, by the ratio of the armature voltages. The armature voltage of the machine as a dynamo is $110 + (90 \times .04) = 113.6$ volts, and its armature voltage during the stray-power test was $110 - (3 \times .04) = 109.88$ volts.

The corrected stray power, which we assume that of the dynamo at full load, would be

$$\frac{1400 \times 113.6 \times 329.64}{1390 \times 109.88} = 343.3 \text{ watts.}$$

If we had two machines coupled together as described in the latter part of the preceding article, we should, as indicated, deduct from the gross input to the system, the C^2R losses, and as the speeds of the machines are exactly the same, the result should be divided in proportion to the armature voltage of each. Thus, if the stray power of such a system was 650 watts and the armature voltages of dynamo and motor were found to be 113 and 109 respectively, we should divide the total watts by the sum of the armature voltages and multiply the result by the armature voltage of the machine whose stray power is to be determined. Thus, in this case we have

$$\text{Stray power of motor} = \frac{109 \times 650}{222} = 319.1$$

watts; and, of course, the stray power of the dynamo equals the balance, or 330.9 watts. If the dynamo or motor, according to what machine was under test, was operated at full load commercial conditions, this would be the proper stray-power value to use in the efficiency calculation after it was corrected for speed if necessary, as previously described.

The stray power of a dynamo or motor is only approximately proportional to the speed and to the armature voltage. Eddy-current losses increase with the square of the speed, hysteresis with the speed directly, and friction in a complex and usually lesser ratio. Therefore it is possible that the stray power increases with speed in greater than direct ratio, and it is only approximately accurate to assume a simple proportion for the joint increase of all the losses.

The armature voltage is simply a convenient measure of the field strength with which the losses vary. It will be seen at once that to be a measure of the field strength the armature voltage must be the voltage *generated in the armature*, and not the difference of potential between the brushes. Eddy-current losses are proportional to the square of field strength, hysteresis increases as the 1.6 power of the field strength, and friction increases a very variable amount according to the construction of the dynamo, and it may even be *reduced* by increase in field strength. However, both of these assumptions seem to be borne out with sufficient accuracy to render them admissible. If anything, they err in making the stray power too large.

A word about direction of rotation and field connections will not be out of place here. With shunt machines it is always better to separately excite the fields. This throws their losses out of the calculation altogether, and renders the system independent of connections with regard to rotation. The motor is started and the dynamo field is so excited that the machine agrees in terminal potential, both in magnitude and sign, with the mains, with which it is then thrown in multiple. Where it is necessary to include the fields in the test, remember that a given connection of the fields and armature of a machine dictates the direction in which it can be run as a dynamo, and that if operated in the opposite direction it will refuse to excite itself. Therefore, if the direction of the rotation of the system is fixed, the dynamo must be connected to generate when driven in that direction, and the motor must be connected to drive the system in accordance therewith.

The direction in which a dynamo must be turned, and the direction in which a motor will turn, can be reversed at will by reversing either the field or armature terminals, but not both. Bearing these facts in mind the connections of any of these tests should not prove difficult.

Mechanical couplings between similar machines are always easy to make, provided that the machines can be accurately aligned. A common and convenient method is to line up the shafts, slip the pulley over the joint, and securely key it to both shafts. This is a much used method in cases where the losses are to be supplied mechanically, for the common pulley forms a convenient method of supplying power to the system. It is not to be recommended as a permanent fixture, as it is lacking in strength.

There are numbers of shaft couplings on the market that grasp the shafts they con-

nect by friction, and these are peculiarly well adapted to connecting such motors together. A flexible coupling, such as was described in the September number, can be used to good advantage. Belts and gear connections are undesirable, for the losses they entail swell the stray power, and it is almost impossible to do more than guess at them if their estimate is attempted. Gears are admissible in testing railway motors, for the result will be the efficiency at the car axle, which is really what the purchaser cares for. The pinion efficiency is, of course, higher, but in this case is analagous to the electrical efficiency of the dynamo—of theoretical interest only. In testing railway motors using gears, there is very little difficulty in aligning the machines. A piece of shaft the size of the car axle and of sufficient length is necessary, and if both of the machines are connected thereto in the usual way, the shaft will be found to be stiff enough to largely compel the machines to align themselves. The shaft carrying the gears should turn freely by hand after the motors are bolted down, and for that reason it is well to postpone meshing the gears with their pinions until after this adjustment is made.

SUGGESTIONS FOR ELECTRIC RAILWAY PRACTICE.

MAINTENANCE.

BY WALTER MUNROE.

Anyone having occasion to look over any of the smaller electric railroads cannot but be impressed with the difference in their manner of maintenance.

It will be found that the various roads are operated in good, bad and indifferent fashion, and if their maintenance expenses were compared, there is little doubt but that these expenses would correspond with their manner of maintenance.

There are many roads which, to judge from the condition of their apparatus sent in for repair, do not look it over or attend to it until there is a complete break-down.

Now, the maintaining of a road in a proper manner means, among other things, a regular and thorough system of inspection, and assuming that we have decided to adopt this method, it now remains to see *how* it may be done and *how much* should be done. As the different roads are run under widely different conditions, and are operated by apparatus of different makes, it follows that methods that may apply to all should be somewhat general in their nature. However, many points are common to all makes of apparatus.

Let us consider the question of the condition of the track and roadbed of a road. When a railway corporation is negotiating for a franchise to lay tracks in a certain district, it may meet with opposition, and if it finally lays them it may be obliged to do so subject to certain conditions. That is to say, the track must be laid on a certain side of the street, its curves round corners must conform to certain limitations, or it may be that a turnout can be put only on a steep grade when the best place for it would be on a level near the grade. We will assume that it is known that these places in the road are not what they should be, and that the cars consume an excessive amount of energy at these points.

Then the question is, How much is this excess and how can we determine it most easily and quickly? Then having ascertained these points, will it pay to make alterations in the track?

Well organized electric railways have at their command, diagrams and plans of the car wiring, station wiring, feeders, line, etc.

Now why not go a step farther, and (from tests) make out a diagram of the performance of cars at different parts of the line? So that by referring to this diagram, we could say, within reasonable limits, what the speed, current consumption and line voltage would be at any part of the road, under any conditions that we have chosen to impose during the test.

At first thought, this may seem to involve a great amount of computation, but we shall see that it may be made to contain as little or as much of it as we please. The method in outline is this:

A car is taken, of the type usually operated over the part of the road under consideration, equipped with instruments and observers and sent over the road.

The instruments required are a voltmeter reading to 600 volts, two ammeters if it is a double motor equipment, and some form of speed recorder. One ammeter should be *not less than* 100-ampere capacity and the other, *not less than fifty*. Even then there is a considerable tendency to bend the needle, due to a start under heavy load. It is well to make a preliminary run, in order to determine roughly what the maximum current is likely to be.

If the car is equipped for rheostatic control with two motors, one ammeter only may be used, as the motors are always in parallel, and the second ammeter would merely serve to show whether the work was divided equally between the two motors. The speed may be obtained sufficiently near for all practical purposes by another method to be described later.

The various readings of current, line voltage, speed, etc., instead of being kept as long rows of somewhat meaningless figures, are lined out to some convenient scale upon plotting paper. The graphical method appeals more to the eye and shows at a glance the entire condition of affairs. Plotting paper in long strips may be easily obtained and is used as follows: The paper comes divided horizontally and vertically by heavy lines, and there should be as many spaces between these *heavy horizontal* lines as there are *classes* of observations made, *i.e.*, one for current, line voltage and speed, respectively. The space between the heavy lines is divided by finer lines into smaller squares, usually ten on a side. The horse power or kilowatts may also be figured out and plotted.

Horizontally we lay out the *time* from the starting point. So that, at any point shown as so many minutes from the starting point, we may lay out vertically above it (to some convenient scale) the current, line voltage, etc. Then if the readings have been taken at sufficiently frequent intervals (within ten or fifteen seconds), we may join the similar points by lines, thus giving a continuous record.

The diagram shows in a general way, the manner of connecting the instruments into the circuit.

The diagram (Fig. 1) as it stands is intended to apply directly to a car equipped with General Electric apparatus having K controllers. The same general idea would be followed out for a car equipped with other apparatus, and modifications suitable for two other cases will be taken up later.

One ammeter is placed in the main circuit before it reaches the controller, and shows the total current used by the car. The other ammeter is placed in one of the motor circuits and shows the current taken by that particular motor.

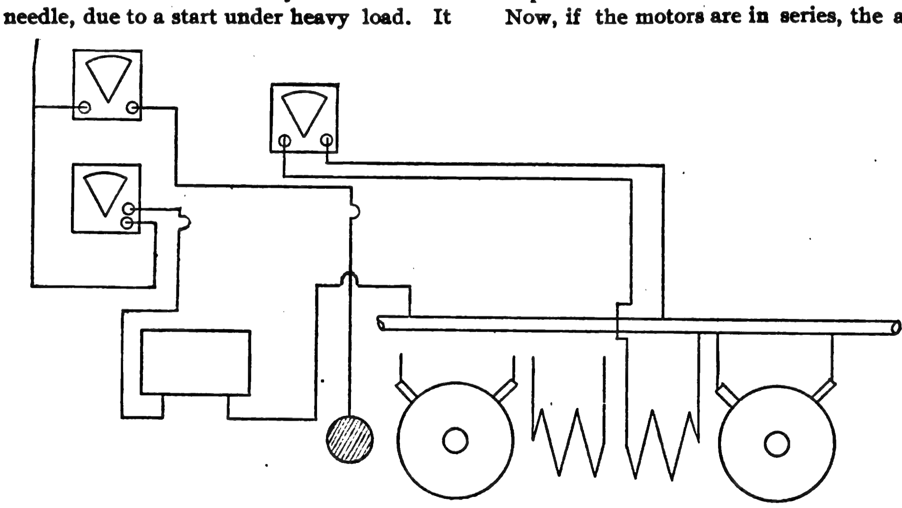


FIG. 1.—DIAGRAM OF CONNECTIONS.

Now, if the motors are in series, the ammeters will, of course, read alike, but if they are in parallel, the difference of their readings will give the current consumed by the other motor. Each motor should, of course, take the same amount. This second ammeter also serves to show, by comparison with the first one, whether the motors were in series or in parallel at any point of the road.

One voltmeter lead may be connected either to the hood switch or to the main circuit near the ammeter. The other voltmeter lead is fastened down under a nut, or in any way to get a good contact, on the motor frame or car truck.

There are at least two places where the main circuit may be opened for the insertion of the ammeter. One is at the hood switch and the other, which we think is in general the best, is at the fuse box.

In many of the closed cars, where the cables are run partly under the seats, the main wire after traversing the hood switches comes down a corner post, and goes through a hole in the floor to the fuse box. Now, if this latter end be disconnected from the fuse box, and pulled up through the hole in the

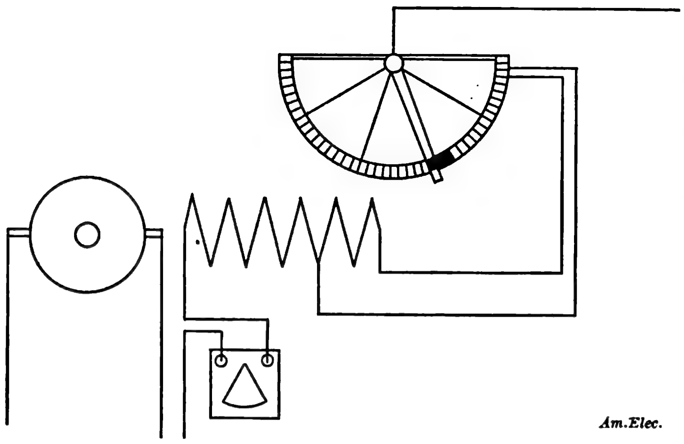


FIG. 2.—DIAGRAM OF CONNECTIONS.

floor, the ammeter may easily be inserted in the circuit, an insulated wire from one binding post going to the fuse box through the hole in the floor, while the other binding post is connected to the short lead from the cable. The other ammeter is placed in the circuit of either motor, as most convenient. An easy way is to take up the traps in the floor and open the circuit where the regular leads from the motor are connected, by double connectors, with the short leads from the cables.

It may save some time and annoyance to give some cautions as to connecting an ammeter directly in the motor circuit.

When a street car motor is reversed, it is done by reversing the current in *either* the field or the armature.

Consequently, we should be careful to place the ammeter in that part which is not reversed when the car goes in the opposite direction. The General Electric controller reverses the armature connections, while the Westinghouse and the Walker controllers both reverse the field to get the same effect, the Westinghouse Company in its No. 28 and No. 28A types, and the Walker Company in its type E controller. There is another case that it may be well to mention, and that is where we have a car equipped with rheostat control and W. P. motors of the General Electric Company.

Here we have a single wire going from the trolley to the rheostat, but two from the rheostat to the motor. Now if the ammeter is put into either of these leads *entering* the field, there will be a time when it will show no current whatever, as then the rheostat contact arm covers the other lead. This may be readily seen from Fig. 2.

On the last point giving the highest speed of the motor, part of the field turns are cut out, weakening it. The proper place for the ammeter is in the field lead where the current *leaves*.

In this case, to change the direction of the car, the armature leads are reversed by a special reversing switch. So much for the energy consumed by the car.

Now as to the speed, two methods of getting it will be described. The first is by the use of the Boyer speed recorder (Fig. 3). This instrument gives a continuous record of the speed of the car in miles per hour on a strip of paper fed along automatically. The entire arrangement is enclosed in a compact iron case and all parts are thus protected from injury. The only exposed part is the grooved wheel used for the belt that runs to it from a pulley on the car axle. As the instrument is ordinarily made, the paper strip is divided by vertical and horizontal lines used as reference points, and travels horizontally at the rate of $\frac{1}{2}$ in. for every mile of the car.

Each $\frac{1}{32}$ in. rise on the paper shows a speed of 1 mile per hour.

The large grooved wheel on the machine is belted to a specially designed grooved pulley, placed on the car axle. This pulley is of such diameter that the paper ribbon will move $\frac{1}{2}$ in. for every mile traversed by the car.

It is assumed, of course, that the car wheels do not slip, and unless this axle is exerting power they will not be affected appreciably. The manufacturers of the apparatus will send a pulley of suitable diameter, if supplied with the necessary data.

Inside the machine is a rotary pump supplied with oil. When the wheel revolves the pump works, and the pressure of the oil is directly proportional to the speed of the car. This pump is piped to a cylinder having a piston movable in a vertical direction. To the upper end of its piston rod is fastened a yoke, and to this yoke two coiled springs that act against the upward motion of the piston or against the oil pressure. Now, these springs are so adjusted that when the speed of the car is 1 mile per hour, the oil pressure is sufficient to stretch them $\frac{1}{32}$ in. To this yoke is fastened a wire that marks upon the paper. The paper has a chemically prepared surface, in order to lessen the pencil friction necessary to make a distinct tracing. The paper ribbon is unwound from a reel, passes partly around a metal drum, and is then wound upon a second reel. The mark is traced on it where it passes around the metal drum. We now see that the paper is moved along horizontally at a rate proportional to the distance covered by the car, and that the pencil has a vertical motion at all times proportional to the speed of the car, the combination of these two motions giving a wavy line, a continuous record. Then, at any point, counted off as so many miles from the starting point, we have the speed recorded vertically above on the paper.

The instrument is provided, also, with a gauge that may be piped to the oil supply. It will then indicate on the dial the speed *at any instant*. If a continuous-speed record is not wanted, but only for certain small sections of the road, this dial may be conveniently used, it being read at the same instant with the voltmeter and the ammeter.

For best results it should be belted to an axle that is not exerting power, as there is then little chance for wheel slippage. If the instrument can be set up so as to be conveniently reached when in operation, it may be well to mark on the paper at certain points of the route that are known distances from the starting point. This will check up any error due to wheel slippage, and also furnish convenient reference points.

This instrument, as ordinarily made up, is designed for use on steam railroads. Consequently it is rather better adapted for higher speeds and longer distances than are met with in electric railway practice. This would tend to render the record hard to read at low speeds. By the simple expedient of speeding up the wheel on the instrument, we can get rid of this effect.

For instance, it might be caused to revolve at twice the speed as called for in its original designs. This can be done easily by changing the diameter of this wheel, the pulley on the car axle, or both. As it often happens that it is quite difficult, if not impossible, to properly attach the instrument to a car, the following method is proposed for obtaining the speed, which may be made accurate enough for all practical purposes. By a simple expedient most of the calculating is eliminated and it can be applied directly to the track diagram.

We will assume that readings are taken every fifteen seconds, for a given period. Here we get the speed by some method that will show the revolutions and fractional revolutions of the car wheel. This may be done

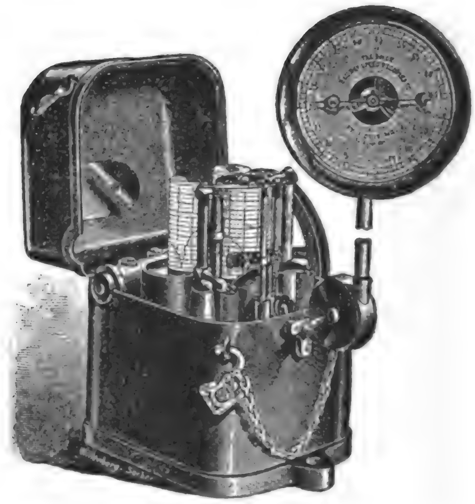


FIG. 3.—BOYER SPEED RECORDER.

by a bell rung by contact-pieces completing an electric circuit through the car axle, or by a dial having a revolving hand belted to the car axle. A portable tachometer belted to the car axle would be an excellent thing, but this method is suggested to take the place of one.

In plotting this, the horizontal spaces are all equal, as we have a "time base." As reference points, the streets, hills, turnouts, etc., may be put down at the time of passing them. If a profile map of these sections can be obtained, it is a good plan to put on the per cent. of the grades as they are passed.

Suppose now that we have taken our wheel revolutions for 15-second intervals over the part of road under question. Let us proceed to put this on the diagram as miles per hour.

Now, the average speed, in miles per hour during 15 seconds

$$=\frac{(60\times 4)\ (\text{circ. of wheel})}{5280}$$

(revolutions of wheel during 15 seconds)

$$= k\ (\text{revs. of wheel})$$

K being the constant for entire test.

Now proceed to find (revs. per 15 seconds) for the maximum speed that is likely to be attained. Assume 20 miles per hour for a maximum. Then take the space allotted on the plotting paper for the speed and mark off vertically in convenient units 5, 10, 15, up to 20 miles per hour. Then divide a distance equal to the space 0—20 into as many equal parts as there are revs. per 15 seconds in a speed of 20 miles per hour.

A pair of fine pointed drawing dividers, will do this nicely. Then make a scale out of some kind of wood or stiff, smooth cardboard, and mark out on this a distance equal to the length of the maximum speed as placed on the plotting paper. Mark out on this the equal distances as found above, numbering points at convenient distances; every five for instance. You are then prepared to find your speed, using your scale and the drawing dividers.

At any given time, as shown on the base line, look up the revolutions of the car wheel for the preceding fifteen seconds. Then take this number from the improvised scale with dividers and lay off the distance found, on the diagram, vertically above the time used. Looking back to the scale of miles on the plotting paper, we have the speed in miles per hour.

This us not strictly the speed for that instant, but is merely the average speed for the preceding fifteen seconds. To get it more nearly we should take the speed readings a half period ahead or behind the other readings.

Let us work through a case, for the revolutions of the car wheel during fifteen seconds when the car has a speed of 20 miles per hour.

At 20 miles per hour we have

$$20 \times 5280 = 105{,}600 \text{ ft. per hour,}$$

$$\text{or } \frac{105{,}600}{240} = \text{ft. per 15 seconds.}$$

Assuming a 33″ wheel = 8′.63 circum.

$$\text{We have } \frac{105{,}600}{240 \times 8.63} = 51 \text{ revs. per 15 seconds.}$$

Now it would be much more convenient to divide the space into fifty instead of fifty-one parts, and the error in so changing would be only about 2 per cent. This may be considered to be of little moment in work of this character.

In getting the performance of a car for an entire round trip, the watt-hours per car mile, or per trip, are usually obtained. The best way is by the use of a recording wattmeter. To get a fair average it is customary to make a number of trips, reading the wattmeter at the start and again at the end of the run. Then dividing the difference by the number of trips, or by the miles covered as the case may be, we have the desired result.

The field or current circuit of the meter is connected in the main circuit of the car where convenient, and the armature circuit across the line. It is well to have some convenient means of stopping the meter when necessary. This may be done by inserting a small switch in the armature circuit.

You can also get values of the watt-hours for certain sections of the road only, running over it a number of times to insure good average. This may, of course, be done at different speeds, controller positions, etc., at the will of the operator.

There are, of course, many ways in which tests of the above nature may be carried out, and the effort has been to indicate *some* of the ways that may be useful. They may be modified in a variety of ways to suit different conditions of affairs.

These methods, or modifications of them have been successfully used by the writer upon a number of electric railways.

PISTON VALVES.

The plain slide valve developed into a piston valve by a very natural process of evolution. Compare one of the "balance-plate" valves described in the last issue, with the valve illustrated by Fig. 1, presented herewith; it will be found that they are almost identical. Or, I might go a step farther and compare the piston valve with a rolled-up slide valve. The good points of such a form of construction are many. Among them are the facts that the valves are almost perfectly balanced, and that the wear is consequently very slight because of the light friction between the valve and its seat. This also means that the power required to operate the piston valve is much less than that required for most forms of slide valves.

The great defect of piston valves lies in their being made loose by wear. The slide valve becomes tighter, the more (within limits) wear it is subjected to, but the piston valve becomes more and more leaky from the day it is started, until it has to be taken to the shop for repairs. Many builders of piston-valve engines have made attempts to overcome the tendency to become leaky, and a good many ways of so doing have been tried. One form of piston valve, which will be described later, has the piston made adjustable so that it can be expanded as it wears, up to a limit of about one-sixteenth of an inch.

Some engine builders make a bushing for the valve to work in, and when it becomes leaky, it is only necessary to remove the old bushing, slip in a new one, and the valve is tight again. But the best method, and one that is employed by the more advanced engine builders, is to make the wearing surfaces of the piston so very long that it is a long time before they can wear enough to show appreciable leakage. This seems to be the best practice in piston valves, and when combined with the renewable casing, a form of valve is secured which seems to leave little to be desired, as far as the mechanical construction is concerned.

In Fig. 1, a form of valve is shown where steam is at all times pressing against both ends with full boiler power. This forms a perfect balance if the area of the rod be neglected. It has the advantage of a very

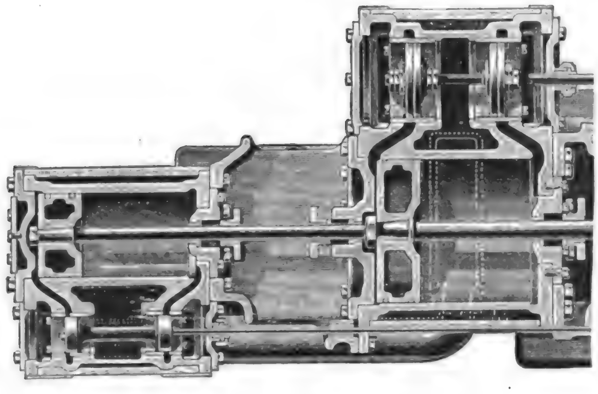


FIG. 1.—PLAIN PISTON VALVES.

large port area, which can extend entirely around the circumference of the valve, only deducting narrow strips between the openings, which must necessarily be left for strength. To put against this, is the considerable clearance which such a large port opening must make necessary, but against this, again, is the nearness to the ends of the cylinder to which the ports may be located. There is no necessity for carrying the steam ports to the middle of the cylinder in order to get a valve with so small bearing surface that the engine will be able to do some work other than running its own valve.

In Fig. 1 the high-pressure valve is made solid, while the low-pressure valve is adjustable a little for lap. This enables the low-pressure distribution to be controlled to a certain extent, and adjusted according to the service required of the engine. By giving considerable travel to these valves, the cut-off can be made very sharp, as the over-travel permits the valve to be moving quite fast at the time when the pistons pass the ports.

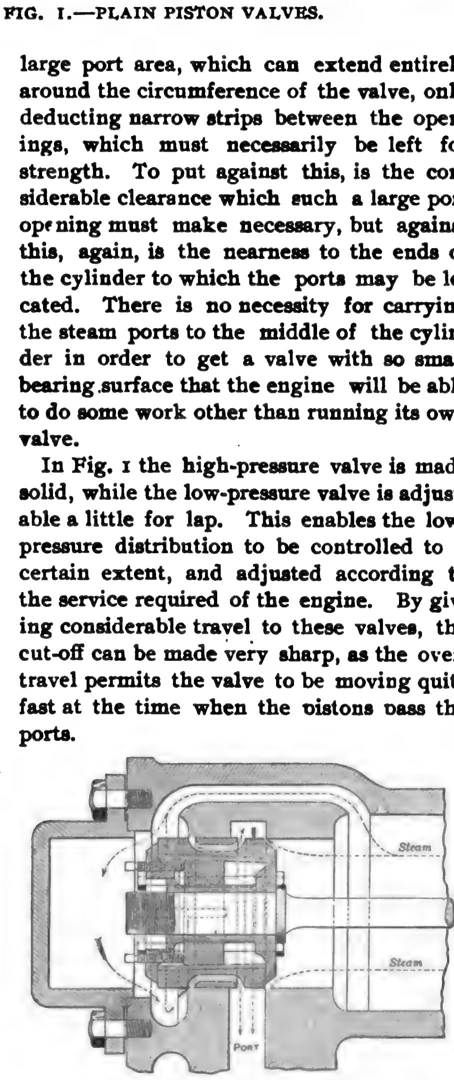


FIG. 2.—"EXPANSIBLE" PISTON VALVE.

About all the variety found in slide valves will be found reproduced in the piston family. The double-ported valve is made as shown by Fig. 2, and being used for steam admission only, there being thus no complicated arrangement of exhaust passages. This valve also has both ends exposed to boiler pressure, and it is so built that by tightening up the set-screws shown at the head end of the piston, the valve may be expanded to compensate for wear. This valve is used on an engine of what might be called a modification of the Corliss type. The valve is actuated from a wrist-plate, the pin of which travels in the concentric arc of the

cam during more than half of its travel without moving the valve. Then, gradually starting, the valve approaches the edge of the port, when the cam, by the form given it, throws the valve open very suddenly. It remains at rest until cut off, when it closes

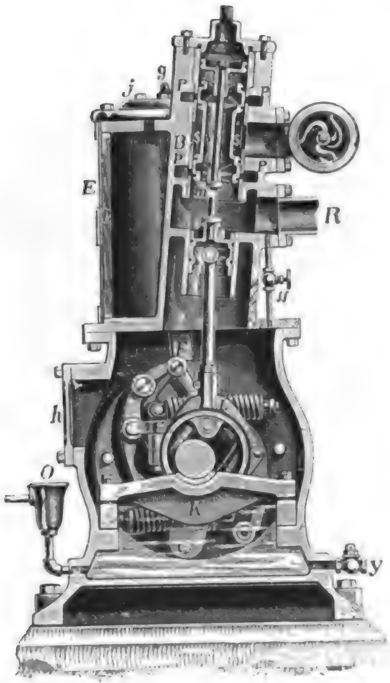


FIG. 3.—FOR TWO SINGLE-ACTING CYLINDERS.

very suddenly. This valve is given just enough travel to fully open the port, and, the bearing surfaces being very long, the setting out for wear is only used about once a year, when an hour's attention is said to be all that is required for another year. Four valves are used on a cylinder, two on the same stem for steam, and two more on another stem, and actuated by a rocker arm, controlling the exhaust.

A peculiar form of piston valve is shown by Fig. 3, where a single-piston valve is used to distribute steam to two single-acting cylinders, both for admission and exhaust. This valve is said to be perfectly balanced, the friction of the rings and inertia being all the retarding forces the driving power has to overcome. In regulating, this valve increases the compression as the steam is cut off shorter, thus causing a saving at both ends—not only admitting less live steam, but compressing up to boiler pressure more of the exhaust steam when the work is very light.

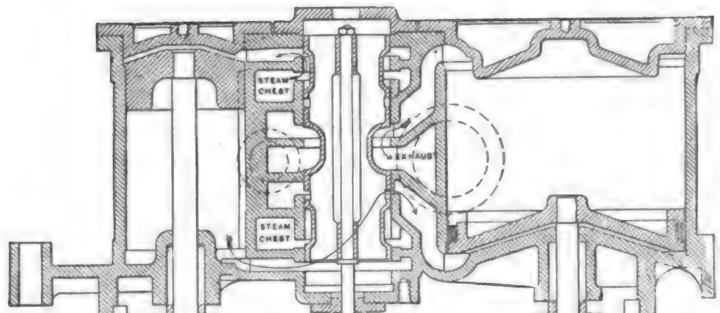


FIG. 4.—SINGLE VALVE CONTROLLING COMPOUND ENGINE.

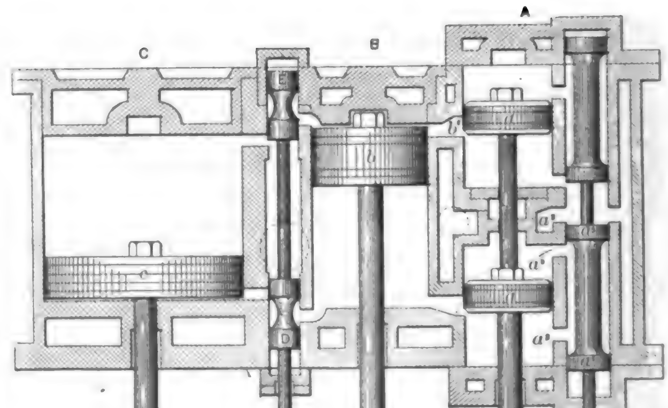


FIG. 5.—REDUCING RECEIVER BACK PRESSURE.

Its action is as follows: Steam enters at the throttle, and surrounds the valve in the chamber, *s*, *s*, and is admitted to the top of each cylinder alternately, as the inside edges of the valve uncover the ports, *p*, *p'*. The compression is controlled by the outside edges of the valve in the usual way. The exhaust into the top of the valve chamber finds its way to the exhaust pipe through the hollow neck of the valve. Port *p* communicates with the top of the right hand cylinder, and *p'* with the left hand cylinder. This valve is the reverse of those shown by Figs. 1 and 2, for the reason that they take live steam at the ends of the valve, while Fig. 3 receives boiler pressure between the heads, has exhaust steam beyond both heads also inside the valve, which in itself becomes a part of the exhaust steam passage.

Fig. 4 shows another single-piston valve controlling two cylinders, and they are double-acting cylinders too. This valve does the entire distribution for the two cylinders which are compounded. In this case, neither high pressure nor exhaust steam gets into the valve, for it acts as a receiver, the space inside it being filled with steam from the high-, in transit to the low-pressure cylinder. The cranks are coupled at 180 degs. The valve is placed at one side, and partly between the two cylinders, forming a very compact arrangement with short steam ports.

It has been found that back pressure in the receiver acts as a considerable opposing force to the high-pressure piston, and a system of piston valves has been devised to prevent this action. Fig. 5 illustrates the method by which it is expected to accomplish the desired results and also to furnish full pressure of steam in the intermediate cylinder, without increasing back pressure in the high. To this end, the travel of the valve in the high is changed, being controlled by a governor. High speed of the engine, when desired, as in marine work, is also provided for by changing the point of cut-off in the high, thus allowing full pressure in the early part of the stroke in the intermediate cylinder. This, of course, allows great speed, but at the expense of economy. When thus running, the chamber, *a*, is entered by the steam after passing through an opening between the two piston valves on the same stem. This passage is opened to the upper piston, *a*, when it passes the bottom center, the cut showing it in the act of closing.

When working as a triple-expansion, the valve closes when the piston reaches the point, b_2, which allows steam to enter cylinder *B* above piston *b* at full boiler pressure; but the crank to cylinder *A* is on the quarter where it moves at the highest speed, while the crank to cylinder *B* is passing its center at its lowest speed, so that piston *a* will travel well in toward the end of its stroke before cylinder *B* will rob it of very much of its pressure.

It will seen that by changing the travel of the valve to cylinder *A*, a full pressure of steam will continue to flow until the piston, *a*, has traveled on toward the end of the stroke; piston *b* also receives the same pressure until valve a_6 closes port a_9, then both work under expansion till the piston, *a*, reaches the end of its stroke, when the valve, a_6, will have moved down far enough to have opened port a_9, which opens a passage through a_8, thereby forming an equilibrium on both sides of the piston, while the steam expands as piston *B* moves down.

It will also be seen that lower piston *A* reaches the top of its cylinder at the same time, but instead of being in a position to exhaust, as in the upper one, it will be in position to receive through lower port a_9, valve a_6 having moved down far enough to open. The piston, *A*, then starts on the return stroke, which requires no explanation. Pistons *C* and *B* are both passing their centers, both receiving steam and both cylinders exhausting at the same time, the receiving of which has already been explained for cylinder *B*.

The steam that was used in the previous stroke remaining in cylinder *B* and lower one, *A*, is about to be used in cylinder *C* to push the piston, *c*, up; this is accomplished with valve *D*, while the exhaust in the upper end of *C* is controlled by its companion valve, *E*. For this engraving and description, also for several of the engravings immediately following, I am indebted to

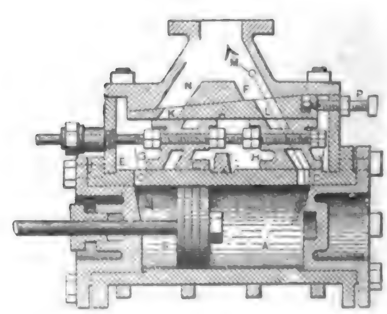


FIG. 6.—"PRESSURE-PLATE" SLIDE-PISTON VALVE.

Power, from the columns of which the engravings were reproduced.

A piston valve with a pressure plate is shown in Fig. 6. The object of this form of

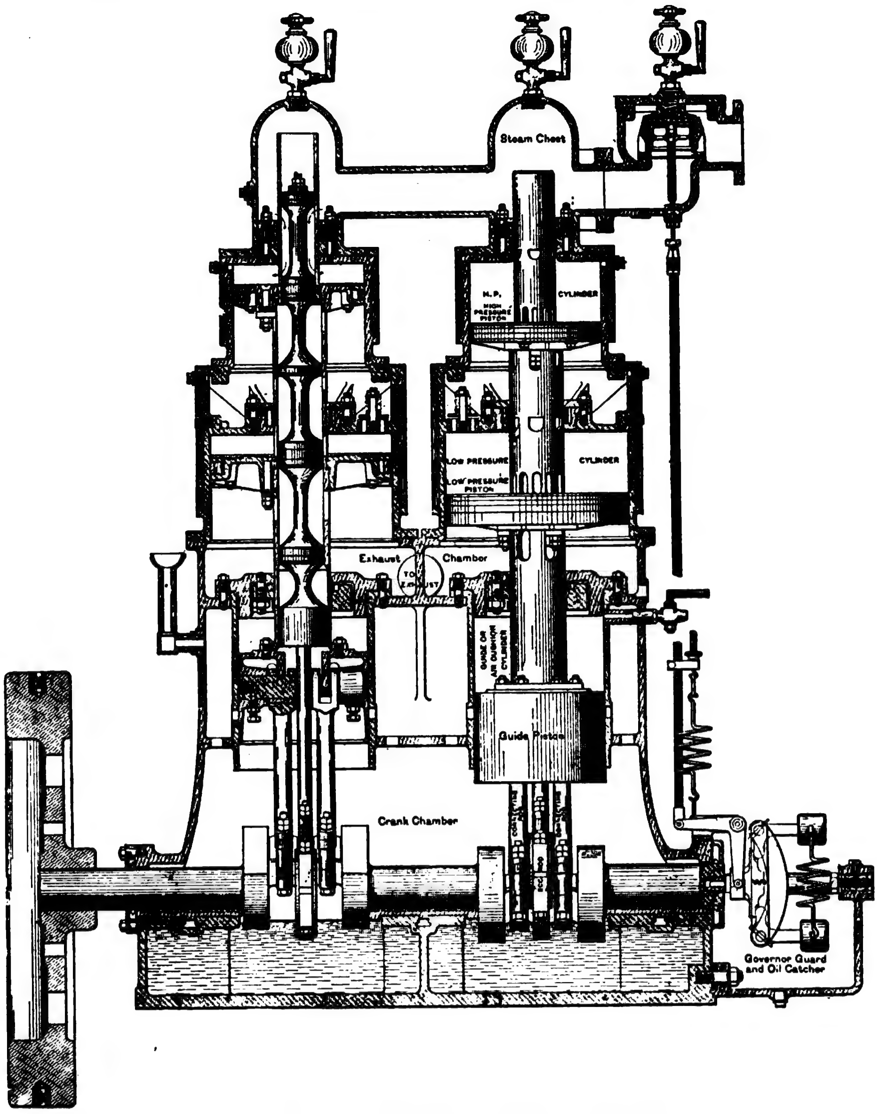


FIG. 7.—VALVES INSIDE OF PISTON ROD.

construction is to secure very short steam passages, little friction, and no leakage. This valve seems to be more of a slide than a piston, and to speak exactly, it should be called a "square piston" valve. Really, it is nothing but two special slide valves adjustably fastened to a rod, and so arranged that work like a piston valve. The exhaust steam, instead of going inside the valve, goes through the recesses and through the slots in the adjustable plate. The clearance is certainly very small with this form of valve, and there need be but little cooling of steam.

One of the most peculiar forms of the piston valve is shown by Fig. 7, where the valve is inside of the piston rod. The engraving shows a double compound engine with a single valve, or one valve formed of three or four on the same rod. The engraving shows the arrangement so clearly that little description is needed, save to state that the eccentric is attached to the crank pin. The valve must move with the pistons, and by attaching the eccentric to the wrist pin, this is secured. Then, by giving the throw required, the valve is given the required relative movement with the valve. The engine governs by a throttling valve actuated by a wheel governor. I am afraid that the excessive clearance will prevent the extensive adoption of this type of engine, even if other things work all right.

Several attempts have been made to change the point of cut-off with piston valves, and one of these is illustrated by Fig. 8. It is nothing more or less than an adjustable (by hand) cut-off, similar to those—in effect at least—applied to throttling engines of a quarter of a century ago. It is nothing more or less than an ordinary piston valve placed within a sliding casing, which can be set by means of a rack-and-pinion movement, to cut off at any point within its range. There is no reason why a device of this kind should not be actuated from the governor, instead of by hand, thus making the engine automatic, with a fixed

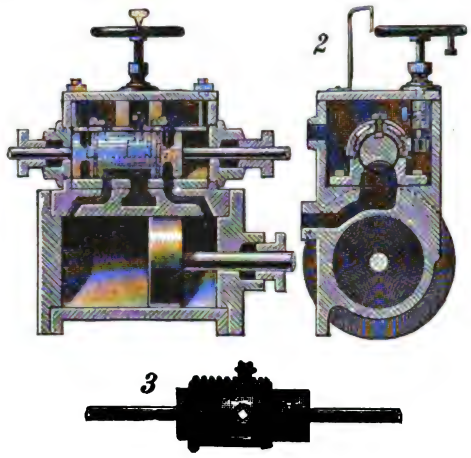


FIG. 8.—HAND ADJUSTABLE CUT-OFF.

admission and compression, but with an adjustable cut-off operated automatically.

In the article on slide valves, one was described in which a riding cut-off governed the admission of steam. This was represented by Fig. 9, in the October issue. The

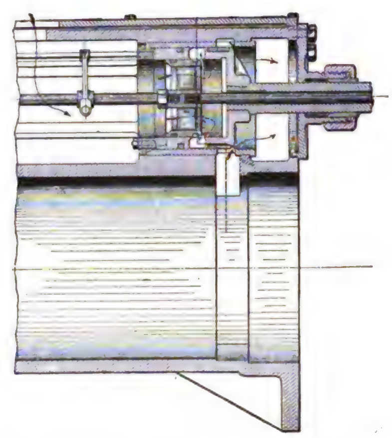


FIG. 9.—"OPPOSITE-MOTION" CUT-OFF.

same effect is secured by a piston valve made by the same engine builders, and this is the subject of Fig. 9. The cut-off is inside of the main valve, and each is so arranged that there is a constant travel under all conditions of load on the engine, thus ensuring equal wear of the valves. The cutting off is done at high speed; the valves moving in opposite directions make this possible, and the variation in time of cut-off only requires that the inner valve move

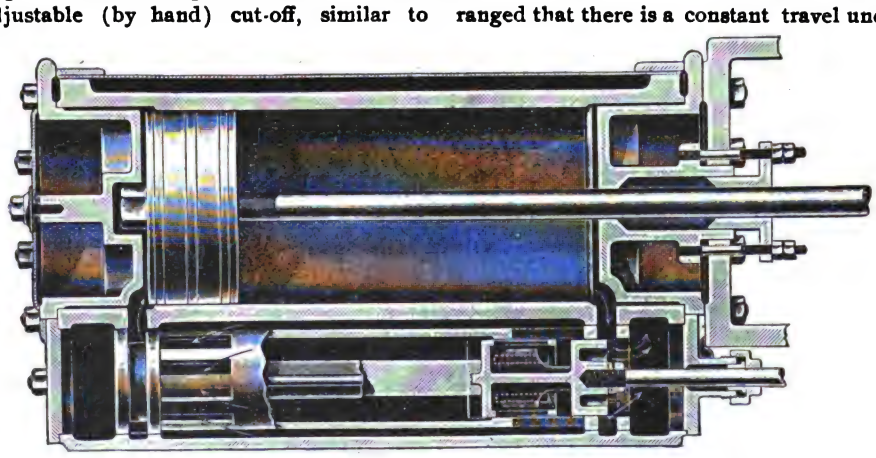


FIG. 10.—PISTON WITH THROTTLING ROTARY CUT-OFF.

early or late according to the position of the wheel governor.

Another type of the "interior riding cut-off," is presented by Fig. 10. Here, live steam surrounds the valve and is admitted through passages near each end of the main valve, then passes to the ports through a channel close to each end. The cut-off is regulated by a sort of "rotary gridiron," which moves endwise with the main valve and, in fact, is attached direct to the valve, stem, but has a rotary movement given it

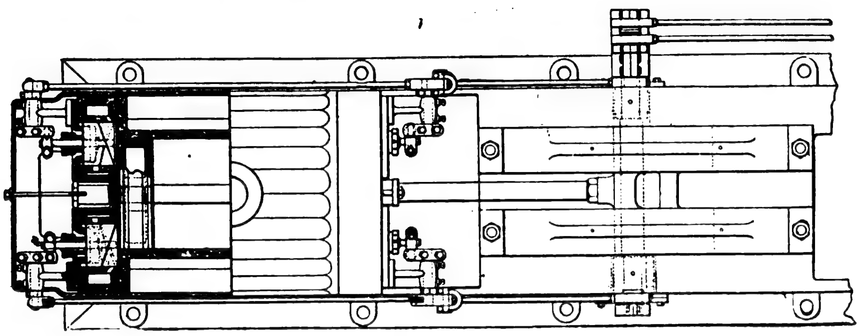


FIG. 11.—"END-CYLINDER" ROTARY CUT-OFF PISTON VALVES.

by the governor, which automatically cuts off steam at the required instant. A peculiarity of the twisting movement is that the eccentric has the same lateral movement, being mounted on gimbals something after the manner of a mariner's compass, and the action of the wheel governor is to move the eccentric sidewise, in fact, to "wobble" it back and forth as the load on the engine demands. It seems to me that the action of this cut-off is not the sudden sharp closure of the steam ports that is demanded by the highest modern practice, but is a mere throttling of the steam in the valve, regulation being obtained in that manner pure and simple.

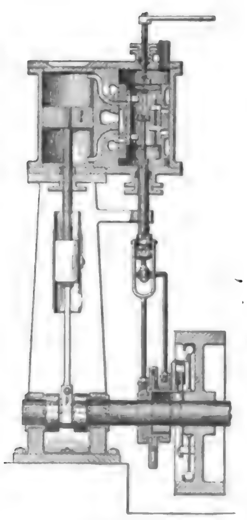


FIG. 12.—REVERSING PISTON VALVE.

A valve very unique in its design and action is illustrated by Fig. 11. Four valves are used, the two admission valves being given a fixed travel by the eccentrics, but the time of opening and closing—closing in particular—is regulated by the governor, which gives the piston valves a rotary motion. The openings in the valve and casings are cut diagonally, so that rotating the valve has the effect of changing the time of opening and closure, instead of wire-drawing the steam, as in the last example (Fig. 10), and cuts it off sharp and clean at the required time.

The exhaust is controlled by the other pair of valves, which are actuated from the eccentric direct, in the manner common to about all four-valve engines. A peculiar feature of these valves is, that they are located directly against the cylinder head, and move in the same direction as the piston of the engine.

A unique and ingenious application of the piston valve is illustrated by Fig. 12, and shows a hollow piston within which is a hollow riding cut-off. The main valve is given a fixed motion by a stationary eccentric, but it is so constructed that it may be revolved by means of the hand lever seen projecting from the top of the valve chest. The cut-off works inside the hollow main valve, and is permanently fixed to a valve stem connected to a second eccentric, or to a part of the first eccentric which is controlled by the wheel governor.

By rotating the outer valve shell, the engine may be started, stopped, or reversed. Another set of ports is brought into use when the valve is rotated, which have the effect of changing the direction of rotation of the engine. The cut-off is so arranged that it does not interfere with the full starting power of the engine from any position. When first starting, the engine takes steam at full stroke, but when the speed increases, the cut-off comes into use automatically, and steam is used expansively. The value of this arrangement for elevator and boat use is evident.

An Electric Club.

The Western Electric Company, of Chicago, has provided two large recreation rooms for the girls employed in its factory. These girls have formed a club called the Occident Club, which has now been in existence for two years. It is self-supporting and entirely managed by the girls themselves. They have fitted up the rooms which have been furnished them by the company, one as a library and reading room, which is also used as a room for concerts, and has a seating capacity of about 500; the other, which is of the same size, has been fitted up with lunch counters and a kitchen. Last month, the Occident Club, on a Saturday, gave a literary and musical entertainment from 4:30 to 5:30, and from 5:30 to 6:30, furnishing refreshments to those who cared to stay. The remainder of the evening was spent in a social way. Over 400 attended the entertainment.

LESSONS IN PRACTICAL ELECTRICITY

INDUCTANCE IN ALTERNATING-CURRENT CIRCUITS.

To illustrate the principles concerning inductance developed in the preceding lessons, several problems involving the same will be taken up for solution.

Suppose we have a choking coil, consisting of wire coiled on an iron core. Furthermore, suppose there is available a 110-volt direct current, and a 50-volt alternating current having the usual commercial frequency of 16,000 alternations per minute, or 133 periods per second; also, that an ammeter for both direct and alternating currents is available. With the above circuits and instrument we can now determine all of the data of the coil, and thus be enabled to know how it will act when placed on an alternating-current circuit of any frequency or voltage.

First, connect the coil on the 110-volt circuit, and suppose that the ammeter shows a current flowing of 5.5 amperes; then, from Ohm's law, $R = \frac{E}{C}$, we find the resistance of the coil to be $110 \div 5.5$ or 20 ohms. This, it may be remarked, would be a very high resistance for the coil in question, but it has purposely been chosen to render more clear the diagrams to be constructed later.

Next, place the coil on the 50-volt alternating-current circuit, and suppose by the ammeter we find that 1.1 amperes are flowing through it; this completes the data necessary for the calculations to follow.

In the above case, for the sake of simplicity the coil is supposed to be directly connected to regular lighting circuits. As a rule, it would not be safe to connect any coil that might be in hand directly to a 110-volt circuit because its resistance would probably be low. In that case, however, another resistance may be placed in series with the coil, such as a rheostat, R (Fig. 1), or a number of lamps in parallel, and the volt-

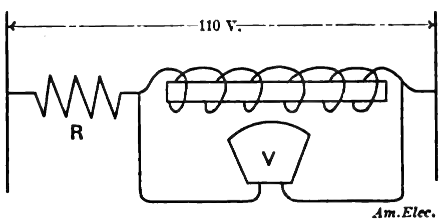


FIG. 1.—CONNECTIONS OF INDUCTANCE COIL.

age measured between the ends of the coil, which voltage will correspond to the 110 in the above case. Should such a coil have but a few turns of wire, it would also be necessary to have an inductance or resistance in circuit with it when connected on an alternating-current circuit; in this case, also, the voltage between the terminals can be measured as in Fig. 1, which voltage will correspond to the 50 given above.

What we now wish to know is the self-inductance (coefficient of self-induction) of the above coil.

The impressed E. M. F. is that of the cir-

cuit or 50 volts. Since the resistance is 20 ohms, the ohmic drop when 1.1 amperes are flowing through the coil is, of course, 1.1×20 or 22 volts, which is the free E. M. F., or the E. M. F. which sets up the flow of current in the coil in the same manner that the free E. M. F. of a direct-current motor (the difference between the binding post and counter E. M. F.) sets up a flow of current through the armature of the motor.

In the case of the motor, the counter E. M. F. would be the arithmetical difference between the E. M. F. at the binding posts and the free E. M. F. In the case of alternating currents, however, this quantity is not the *arithmetical*, but the *vector* difference between the same quantities. That is, instead

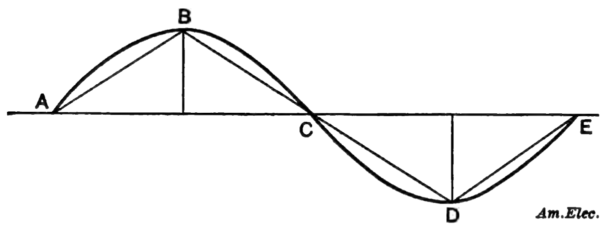


FIG. 2.—UNIFORM AND SINUSOIDAL VARIATIONS.

of subtracting 22 volts from 50 volts, we subtract the square of 22 from the square of 50, and then extract the square root of the difference.

Performing this operation, we have $(50 \times 50 = 2500) - (22 \times 22 = 484)$, or a difference of 2016; extracting the square root of this, we have 45 volts, which is the inductive E. M. F.

That is to say, the impressed E. M. F. or 50 volts is the vector sum of a free E. M. F. of 22 volts and an inductive E. M. F. of 45 volts. We will now proceed to determine the self-inductance that, with a current of 1.1 amperes and a frequency of 133, gives rise to an inductive E. M. F. of 45 volts.

As explained in previous lessons, the self-inductance of a coil is the voltage which will exist at its terminals when a current passing through it rises or falls in value at a uniform rate of 1 ampere per second. If the current instead of being 1 ampere, is 1.1 amperes, we must reduce the voltage shown in the ratio of 1.1 to unity; so that, if we had 45 volts, the self-inductance of the coil under the definition would be $45 \div 1.1$ or 41 volts.

According to the definition, the current should rise or fall through 1 ampere in a time of one second. Referring to Fig. 2, which represents the curve of a single alternating-current period, it will be seen that during a period the current rises from zero at A, to a maximum at B, falls from B to zero at C, continues to fall from zero to a negative maximum at D, and rises from D again to zero at E. In other words, if the frequency of an alternating current were one period per second, the time which accords with the above definition would be one-quarter of a second; but in this case there are 133 periods to a second, so that the time becomes $\frac{1}{4} \times \frac{1}{133} = 1 \div 532$ part of a second, or the rate of rising or falling is 532 times more rapid than that of the definition. Therefore, to reduce the present case to a variation of 1 ampere per second we must divide 41 volts by 532, which gives us .077 volts. In other words, in the coil in question, if a current passing through it varied at the rate of 1 ampere per second a voltage of .077 would be measured at the terminals.

Thus far we have assumed a uniform rate of variation of E. M. F. or, referring to Fig. 2, a variation represented for example by the straight line, AB; but we are supposed to be dealing with an alternating current following the sine form of variation, or the variation represented by the curve between A and B; now, the average rate of variation along the curve, AB, is greater than that along the straight line, AB; and the current is the effective and not maximum value. These two factors cause the inductive E. M. F. to be increased for an alternating current in the ratio of π: 2, or 1.5708; consequently, we must reduce .077 in this ratio in order to comply with our definition. Dividing .077 by 1.5708, we have, finally, .05, which is the self-inductance of the coil in question.

We would advise a student to carefully follow the above argument, as it should give him a good insight into the real meaning of self-inductance (formerly called co-efficient of self-induction). It may seem that the definition is entirely arbitrary, which is true; but all problems into which inductance enters are solved with the above definition always kept in view, as in the above example. No matter what the rate of variation of a current may be, it can always be reduced to a basis of 1 ampere per second; and no matter what the form of variation may be, it may always be taken account of by a coefficient, such as the coefficient of 1.5708, which applies to a sine curve.

Finally, all of the above operation may be very simply represented by the formula

$$L = \frac{E}{2 \pi n C},$$

where E is the inductive E. M. F. (45); n, the number of periods per second (133); L the self-inductance, and C (1.1) the current flowing which gives rise to the inductive E. M. F., E. Substituting, we have

$$L = \frac{45}{2 \times 3.1416 \times 133 \times 1.1} = .05, \text{ as before.}$$

Having now found the self-inductance of the coil, let us see its application. Suppose that the coil is placed on a 100-volt alternating circuit having a frequency of 60 periods per second; what current will flow through the coil?

First, we will find what the impressed E. M. F. will be on the basis of 1 ampere flowing; having found this, the number of amperes that will actually flow will, of course, be in the ratio of the existing line E. M. F. or 100 volts to the E. M. F. found corresponding to 1 ampere.

Since the resistance of the coil is 20 ohms, the free E. M. F. must be sufficient to send 1 ampere through 20 ohms, or $20 \times 1 = 20$ volts.

Since the self-inductance is .05 henry, the inductive E. M. F. for 60 periods per second, or $4 \times 60 = 240$ variations per second, will be $240 \times .05 = 12$ volts; and since the current does not vary uniformly, but according to the sine law, this must be multiplied by $\frac{\pi}{2}$ or 1.5078, which gives us $1.5078 \times 12 = 18.9$ volts, which is the inductive E. M. F.

The same result could be gotten directly from the formula, $E = 2 \pi n L C$, C being assumed in this case as unity. Substituting, we have $E = 2 \times 3.1416 \times .60 \times .05 \times 1 = 18.9$ volts, as before.

The impressed E. M. F. is the vector sum of the free and inductive E. M. F. Therefore, squaring each of these quantities, we have $400 + 357.2 = 757.2$; extracting the square root, we have 28 volts, which is the impressed E. M. F. necessary to send 1 ampere through the coil when the frequency is 60.

If the coil is connected to a 100-volt circuit, the number of amperes will be in the ratio of 100 volts to 28 volts, or 3.57 amperes.

In a similar manner, any problem relating to the above coil can be solved. For example, if it is desired to know how it will act as a choke-coil, multiply the above impressed E. M. F. corresponding to 1 ampere, by the current flowing; if the current is one-half ampere, the coil will choke to the extent of 14 volts.

Now let us lay down the diagram for the case above calculated.

We have found, on the basis of 1 ampere, that the free E. M. F. is 20 volts, the inductive E. M. F. 18.9 volts and the impressed E. M. F. 28 volts. To bring each up to the basis of 3.57 amperes, we multiply by that quantity, which gives us 71 volts, 67 volts and 100 volts, respectively. These quantities are effective E. M. Fs., and as the maximum E. M. F. is 1.41 times greater than the effective E. M. Fs., we have, finally, 100, 94 and 141 volts, respectively, as the values of the maximum E. M. Fs. In Fig. 3 these are laid down to scale, as b, a and c.

The sine curve, B, is the curve of free E. M. F., the maximum ordinate, b, having a value of 100 on the scale of the engraving. The curve of inductive E. M. F., A, has a maximum ordinate, a, of value 94. This curve is drawn so that its zero point comes vertically below the maximum point of the curve of free E. M. F. This follows for the reason, as explained before, that the curve of free E. M. F. may also represent the current curve to a different scale, since it must

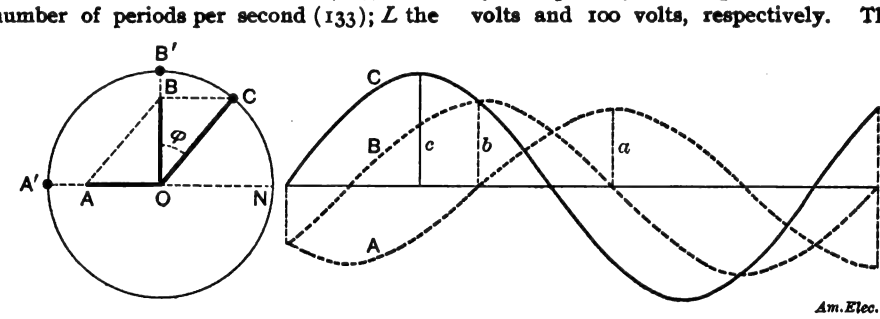


FIG. 3.—BIPOLAR-DYNAMO DIAGRAM.

be in phase with the current which it produces; and as the change of value of the current is zero at its maximum point, consequently the rate of change of its lines of force is then also zero; there are thus no lines then cutting the conductors of the coil, and consequently no inductive E. M. F. at this point.

The curve of impressed E. M. F., *C*, may be obtained through construction by combining the curves of free and inductive E. M. F.* That is, as explained in the previous lesson, the impressed E. M. F. is the sum of the free and inductive E. M. Fs. when the former is increasing in value, and the difference when it is decreasing in value. In this manner we get the curve, *C*, whose maximum ordinate, *c*, has a value of 1.41, both as calculated and as follows from the construction.

Referring to the clock or bipolar-dynamo diagram on the left of Fig. 3, *A O* represents the maximum value of the inductive E. M. F.; *B O*, the maximum value of the free E. M. F.; and *C O*, the resultant of these two as obtained by the parallelogram of forces. If we consider *A′*. *B′* and *C* conductors on the armature of a bipolar dynamo, the gap of which is at *A′* and *N*, then the E. M. F. curve, *A*, would be generated by the conductor, *A*; the curve, *B*, by the conductor, *B′*; and the curve, *C*, by the conductor, *C* —*provided*, that we consider the length of the several conductors *along the face of the armature* to be proportional to the lengths of the lines *A O*, *B O* and *C O*, respectively.

The angle of lag† between the current and impressed E. M. F. is the same as that between the impressed and free E. M. F., since the latter is in phase with the current; this angle is that between the corresponding conductors of the bipolar dynamo above referred to, or the angle, *B O C*. If correctly constructed, the angle measured by a protractor would be 43 degs.

THE "ENCHANTED" RING.

BY REESE HUTCHISON.

Alternating-current experimental work is justly ranked among the most interesting and instructive of modern experimental science. It embraces peculiarities that cannot be ascertained except by experimental study.

The subject of this article, while very simple to a well informed electrician, yet can be made a source of information to all who, not being familiar with alternating-current phenomena, study out the cause of the actions of the apparatus. The data given are for a Westinghouse machine of 125 cycles and 50 volts, 15 amperes. For other conditions the number of turns must be experimentally determined.

Fig. 1 shows a cross section of the completed apparatus, with all measurements for construction. It consists of the two ends of an ordinary 5-lb. wire reel with the circular opening enlarged to receive an iron core of annealed wire cut to equal length and assembled into a circular form, with a diameter of 2½ ins. The ends are secured to the core 3 ins. apart and the enclosed part of the core thoroughly taped. 125 turns of No. 10 B. & S. magnet wire are wound on and connected to the circuit through a switch. A copper ring 2¾ ins. inside diameter, is made from bare No. 2 wire.

Place the ring over the projecting core end and close the circuit into the coil. The ring quickly "climbs" the core and flies away to some distance. Attempt to replace it over the core while the current is in the

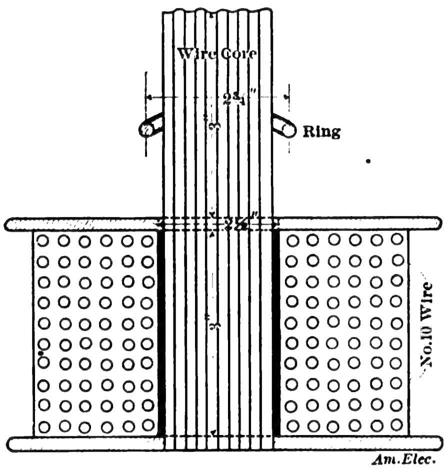


FIG. 1.—"ENCHANTED" RING.

coil and some little strength is required to force it down. Decrease or increase the number of turns, noting the current flowing into the coil at each variation, and note the increased or diminished effect on the ring.

Study out the reason for each result, and any questions will be answered through these pages.

SOME ELECTRICAL SPORT—III.

BY JAMES F. HOBART.

Another scheme—one of the worst for the victims—was worked up, which was the terror of all bad dogs in the neighborhood, and was claimed to be the death of several canines. In roof of station was a large tank built of wood. The tank was placed upon timbers, and was fed by a pipe, which discharged over the top of the tank, as shown at *a*, Fig. 1. The water was nowhere connected with the ground by means of a pipe. The overflow was simply a three-cornered spout as shown at *b*, which projected through a hole in the side of the power house. This tank was for fire purposes, and to prevent the water from freezing, it was heavily charged with salt. A separate pipe, shown at *c*, left bottom of tank, was fitted with rubber hose for fire purposes, in the dynamo room.

The connecting pipe, *c*, was carefully examined to see that it was not grounded. Then a wire was run from the dynamo to the tank, and fastened to a strip of copper placed therein. The water contained enough salt so that it formed a good conductor of

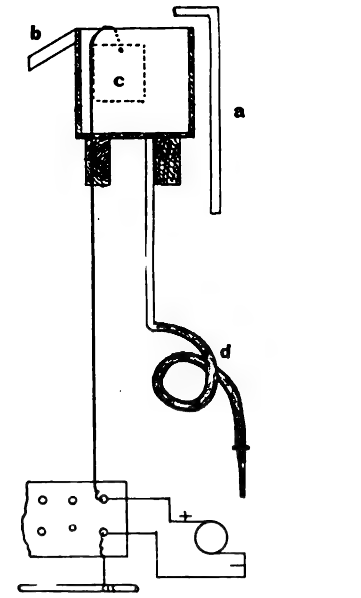


FIG. 1.—WATER AND ELECTRICAL CONNECTIONS.

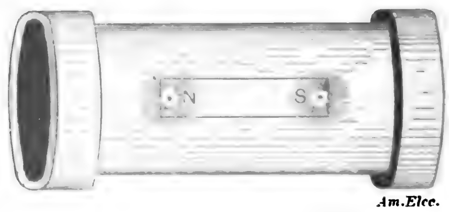
electricity. Whenever a stray dog appeared in the neighborhood (when the "experimental dynamo" chanced to be running), the ground plug was quietly put into switchboard, and a stream of water turned upon the dog. When it hit him, he formed a connecting link from tank of water to the earth for a 1000-volt current of electricity. Sometimes the dog got himself gone in a hurry, and sometimes he was "dog-goned," and left his carcass on earth to prove it.

Letters on Practical Subjects

Locating Cash Carriers.

To the Editor of American Electrician:

The accompanying sketch represents a very simple arrangement I have had in use for some time for locating pneumatic cash carriers that may become stuck in a carrier



PNEUMATIC CASH CARRIER.

tube. I take some old clock spring and cut from it three pieces, which are made magnetic. These are fastened to the leather carrier by means of two rivets in each piece, the pieces being equally spaced around the cylinder. When a carrier has become fast, it is located by means of a common compass, which is moved along the pipe, the compass being deflected at the place where the carrier is fast. G. W. HARROLD,

Philadelphia, Pa.

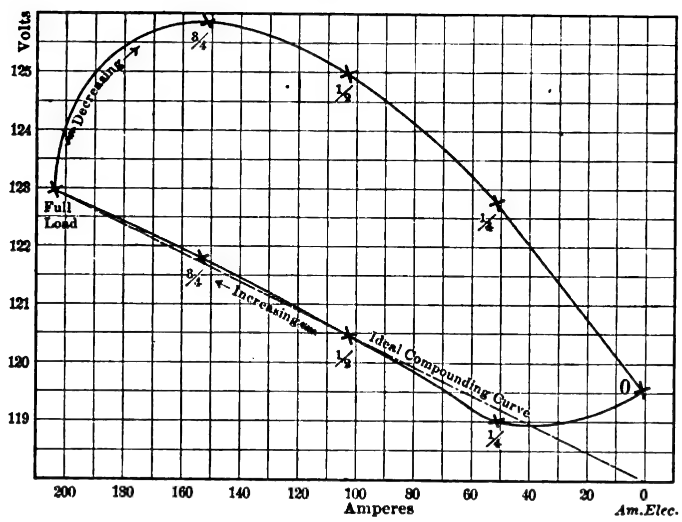
*In the October installment of "Lessons," the ordinates of the inductive and free E. M. Fs. were added algebraically, which caused the current to lead, instead of lag behind, the impressed E. M. F. This was incorrect, as the ordinates of inductive E. M. F., whatever their sign, should be added to those of the free E. M. F. when the latter is increasing in value, and subtracted when it is decreasing. This has been properly done in the case of Fig. 3, and consequently the current lags behind the impressed E. M. F., as it should do.

†From the clock diagram of Fig. 3, it will be seen that the tangent of the angle between *B O* and *C O* is *B C* ÷ *O B*; that is, the tangent = inductive E. M. F. ÷ free E. M. F. In the case calculated we have tangent = [illegible] = .9436 which, by reference to a table of trigonometric functions, we find corresponds to 43 degs. nearly.

Compounding Curve.

To the Editor of American Electrician:

I send in reply to Mr. Thomas' request in the October issue, the compounding curve of a 25-KW multipolar generator, having six poles, giving a full load current of 203 amperes at 300 r. p. m. Though not direct-connected, the curve in no way differs on this account. The machine was over-compounded from 118 to 123 volts, and the current varied in increments and decrements of one-fourth its full load value.



COMPOUNDING CURVE.

As the current falls to zero, the effect of hysteretic lag, or residual magnetism, is plainly discernible in the accompanying curve.

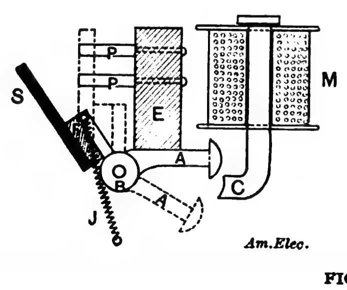
WALLACE K. BUTLER.

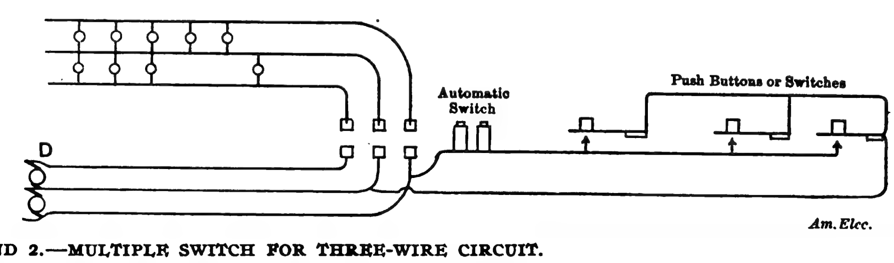
Schenectady, N. Y.

Multiple Switch for Three-Wire Circuits.

To the Editor of American Electrician:

In reply to the request of Mr. T. L. Francis in your October issue, for a sketch showing how to connect up a lot of lamps using a three-wire circuit, so that the lamps can be turned on or off at any one of a number of points, I send herewith two sketches showing how this may be done with very little extra wiring. The lamps are connected up in the regular way, the three mains coming into an automatic switch.





FIGS. 1 AND 2.—MULTIPLE SWITCH FOR THREE-WIRE CIRCUIT.

This switch is operated by an electromagnet, taking its current from the lighting circuit. The resistance of this magnet should be about 100 ohms, as the magnet needs a momentary but very strong current. Any number of switches can be put in. I think push buttons will answer just as well, because there are no switches on the market (as far as I know) which will make contact only for a fraction of a second.

A cross section of the automatic switch is shown in Fig. 1, *M* being the magnet, *S*, one of the three switch-bars attached to a pivot carrying an arm with an armature, *A*; *J* is a spiral spring. The drawing otherwise explains itself. Every time a push button is operated the switch jumps over, either turning the lamp on or off.

In your same issue I notice under "Electrical Sport," a method of giving street gamins a shock, but find it not only complicated, but very dangerous, if some mistake is made. A much simpler, and also safer way, is to get a regular telephone magneto generator and connect it up by a small belt with the main shaft. An old generator can be had in any telephone factory at a low price, and will give a very strong shock, if the speed is sufficient—say, 250 r. p. m. At the same time it might come very handy for testing purposes.

HENRY P. J. VAN DETH.

Brooklyn, N. Y.

Ammeter Shunt.

To the Editor of American Electrician:

It is frequently very convenient to be able to measure currents much smaller than can be read from the ammeters usually found in lighting plants, and a milliammeter is not always accessible. In such cases, where a separate shunt type of ammeter is in use, a special shunt can easily be constructed, which will divide the value of the scale divisions by 100 or 1000.

I have constructed such a shunt for a Weston 750-ampere switch-board instrument, dividing the value of its readings by 100, thus giving me a range of 7½ amperes by $\frac{1}{80}$ ampere divisions.

It is simply a strip of German silver ⅝ in. wide, .015 in. thick and about 6 ins. long. To each end is soldered a double binding screw arranged to take the terminal lug on the leads from the instrument, and also to act as terminals for the instrument. To calibrate, it is only necessary to connect it in series with a standard ammeter and send a current through them to nearly its full capacity, moving one of the binding screws until the reading corresponds to that of the standard. It is necessary to cool the shunt after soldering and before any readings are taken, as otherwise a serious error will arise from the thermo-electric effects.

It is but the work of a minute to change from one shunt to the other, and even though the instrument may be in use, the change will have no effect on the circuit, as the regular shunt need only be disconnected from the ammeter. The convenience of this device will many times repay the slight trouble of constructing it.

EDWARD E. SHELDON.

Rochester, N. Y.

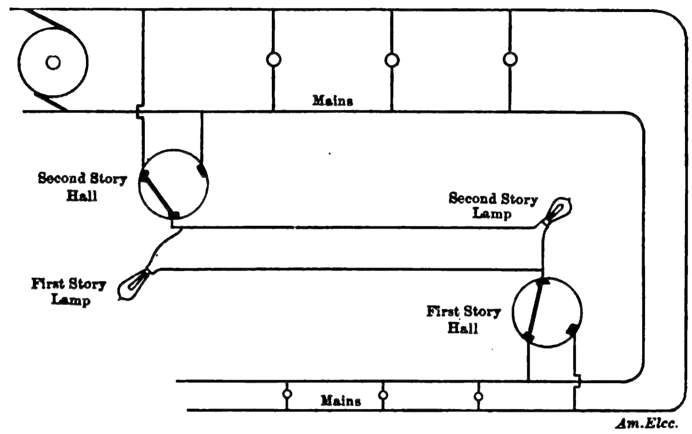
Three-Way Switch.

To the Editor of American Electrician:

The sketch given above shows a three-way switch which I have just completed and found satisfactory. It is different from the others which I have noticed described in the last four issues. It requires less wire and, therefore, less work. I have had no trouble with short circuits since I have had this switch in operation.

F. M. BALES.

Allegan, Mich.



THREE-WAY SWITCH.

Magneto Firing Machine.

To the Editor of American Electrician:

Will some one of your readers kindly tell how to connect up a magneto for firing the exploders used in blasting with powder or dynamite? The machine used for this purpose consists of a magneto in a small wooden case, which stands on the ground. A handle, resembling that of a shovel, projects

from the top of the case. The dynamo is actuated by suddenly moving the handle either up or down, as the case may be. When the handle reaches the end of its travel, contact is made, so that the cumulative current formed in and by the magneto is suddenly discharged into the wires leading to the cartridges in which the exploders have been placed.

I have made a rig of this kind, but can't get it to work right. The magneto is a heavy concern, with four magnets, each ⅞ in. square and 8 or 10 ins. from end to end. It was made to work one of the earlier forms of step-by-step alphabetical-telegraph machines, and gives a current which will shake a man up in good shape. This magneto was operated, when in the machine, by a treadle like that of a common sewing machine. I removed the little pulley and replaced it with a small gear which meshes with a rack fastened to the slide which pushes down. A spring contact is so placed that the end of the rack strikes it at the end of the downward stroke, and it is intended that this action will switch the current into the cartridge-connected wires.

Somehow I have missed it, and the thing don't work satisfactorily. If some reader would give a diagram of the connections of this class of instrument, also explain the philosophy of the "building up" of the current inside of the machine before it is switched out into the cartridges, it would, doubtless, be of interest to other readers besides myself. JAMES L. FRANCIS.

Brooklyn, N. Y.

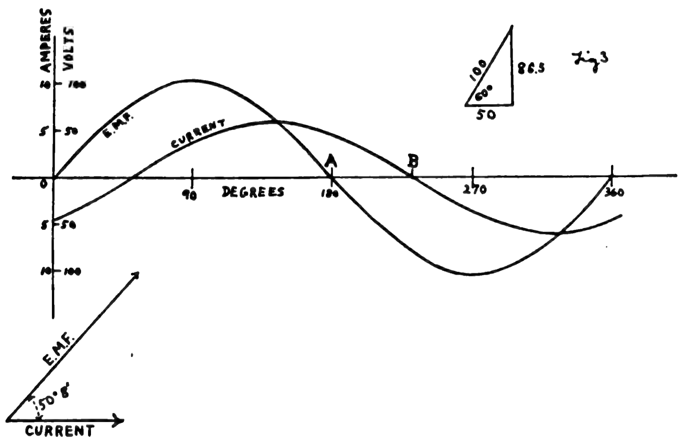
ELECTRICAL CATECHISM

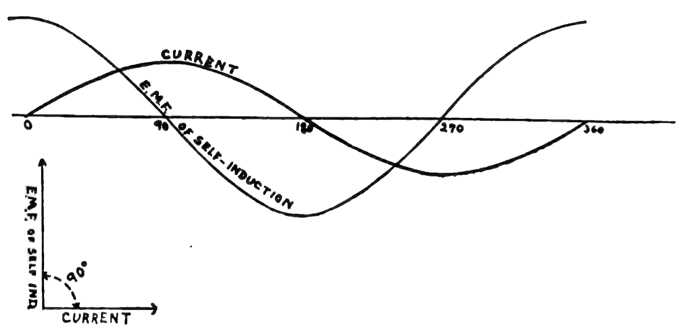
168. What is meant by the "angle of lag?"

This is a convenient method of indicating the "difference of phase" between the current and E. M. F. An alternating current is usually more or less out of phase with the E. M. F. causing it; that is, the current reaches its greatest or maximum value after the E. M. F. has reached its maximum. Current and E. M. F. each take the same amount of time to complete a cycle or complete alternation, but the current is usually a little later than corresponding values of the E. M. F. causing it. In order to measure the amount of this dragging behind, the time of a complete cycle is considered as being divided into 360 equal parts or degrees, the most convenient place to begin numbering being the point where the E. M. F. or current passes through zero. The angle of lag between current and E. M. F. is shown by the distance (measured in degrees) between corresponding values; for instance, the distance between the points where the two curves cross the base line in the same direction, as at *A* and *B*, in Fig. 1.

169. What causes the lag of current behind the E. M. F.?

The self-inductance of the circuit causes the current to lag behind the E. M. F. This may be counteracted by the "capacity" of the circuit, which has a tendency to make the current "lead" the current.





FIGS. 1 AND 2.—ILLUSTRATING ANGLE OF LAG.

170. How does self-inductance cause the current to lag behind the E. M. F.?

In any circuit having self-inductance there is a tendency to prevent changes in the strength of the current. Every current is surrounded by a magnetic field which is caused by, and is proportional to, the strength of the current. When two parts of the circuit are near together, so that one is in the magnetic field of the other, any change in the strength of the current causes a corresponding change in the magnetic field and so sets up an E. M. F. in the other wire. Each part reacts on the other, and in a coil the induced E. M. F. is proportional to the square of the number of turns of wire. This induced E. M. F. is in a direction to oppose the change in the current and is therefore called a "counter E. M. F." In the case of an alternating current, this therefore causes the current to reach its maximum value a little later than the line or impressed E. M. F.; the same tendency also causes the current to hold up after the E. M. F. has diminished. Thus the result of the E. M. F. of self-inductance is to make the current lag behind the principal or impressed E. M. F.

171. Is the E. M. F. of self-inductance directly opposed to the impressed E. M. F.?

No. It is about 90 degs. behind the current and therefore is somewhat behind the impressed or line E. M. F. The E. M. F. of self-inductance is at every instant proportional to the rate of change of the current. When the current is at its maximum value, it is changing least rapidly—in fact, has a constant value for an instant—and therefore the induced E. M. F. at that instant is zero; when the current is zero it is changing most rapidly and therefore the induced E. M. F. is at its maximum value. The E. M. F. of self-inductance is therefore 90 degs. behind of the current, as is indicated in Fig. 2.

172. What governs the angle of lag between the impressed or line E. M. F. and the current?

The lag is governed by the relative values of the various E. M. Fs. in the circuit. In a circuit having resistance and self-inductance, but no capacity worth considering, three E. M. Fs. must be considered, that on the line, or the impressed; that due to self-inductance; that due to the "ohmic drop," which equals the product of current by resistance, as with continuous currents. The ohmic drop, sometimes called the "effective" or "active" E. M. F., is at all times proportional to the current and is therefore in phase with it. As shown above (No. 169), the E. M. F. of self-inductance is 90 degs. behind the current. These are the two components into which the impressed E. M. F. may be resolved, and from which the angle between the current and impressed E. M. F. may be determined. For example, suppose a coil has a resistance of 10 ohms and an E. M. F. of self-inductance of 86.5 volts when the current is 5 amperes. The ohmic drop is 10 multiplied by 5, or 50 volts. To find the impressed E. M. F. necessary to send the current of 5 amperes, lay off on a horizontal line a distance to represent 50 volts to any convenient scale, as in Fig. 3. At the right end of this line erect a perpendicular of length 86.5 to represent the E. M. F. of self-induction 90 degs. ahead of the current and ohmic drop. The line joining the ends of the two lines represents in direction and amount the impressed E. M. F. necessary to send the current through the circuit. From the figure, this is seen to be 100 volts. The angle between the impressed E. M. F. and the ohmic drop, and therefore the current, is seen to be 60 degs. Knowing the angles between the various E. M. Fs. and the current, it would be easy to plot curves similar to Figs. 2 and 3 for this case, following the method given in AMERICAN ELECTRICIAN, July, 1897, page 288.

QUERIES AND ANSWERS

NOTE. *Criticisms and extensions of the answers given in this column will be welcomed. Windings of amateur motors and dynamos cannot be supplied, as such designs rarely justify the labor required for the calculation; the complete series of designs of small machines now being published in this journal will usually furnish data for other small machines, if intelligently applied.*

What material is used to fill in the top of Leclanché porous cups? G. J. G.

Pitch; the addition of some gutta-percha will render the material less friable.

How are the glass disks made for the induction coil described in January issue? C. J.

Drill with a brass tube, emery and turpentine, using a fiddle bow to rotate the tube.

How many lines of force per square inch do wrought iron, magnetic steel and cast iron carry in practical working? G. B.

About 100,000 in the two first-mentioned and 50,000 in the latter.

In making a core for a 3-in. induction coil, could I use a thin sheet-iron tube to enclose the soft-iron wire of the primary core? D. H.

No, for the reason that this would form a secondary to the primary and reduce the power of the coil enormously.

The to-and-fro play of a shaft in its bearings is sometimes referred to as "oscillation." Is this correct? R. G. C.

No. An oscillation is a periodic motion, such as that of a pendulum, while the motion of a shaft is merely a to-and-fro play having no definite period.

How should a 4-pole, 220-volt, 15-HP motor and automatic rheostat be connected to the mains of a 110-volt, three-wire circuit? What size wire should be used, the distance being 50 ft.? J. R. W.

Cut the rheostat into the armature circuit; that is, into the lead from one of the brushes. Connect motor terminals across outer mains. Use No. 4 wire, or larger.

I have some cells with bichromate of potash in the porous cup, which also contains the carbon, and sulphuric acid in the jar. After the cells are charged the fluid in the porous cup begins to rise and overflows. What is the matter? F. S.

The porous cups are apparently not of proper quality, not being balanced osmotically. Try diluting the bichromate solution.

It take 8 cells of carbon battery and a 15-in. spark coil to work a certain gas engine. Could a dynamo be driven by that engine to furnish current for igniting while the engine is in motion? W. A. L.

A small motor, such as a fan motor, could be driven as a dynamo from the engine, its current supplying an induction coil, the secondary of which would be in the igniting circuit.

Please give formula for calculating electric-railway feed wires? .S.

The resistance of the feeder is the allowable drop in volts, divided by the current corresponding to that drop. The calculation of feeders, however, involves many other considerations, and is an engineering problem. See Bell's "Power Distribution for Electric Railways."

1°. What kind of a dynamo should be used to supply current to charge copper plates over which gold tailings run, the gold being retained by the charged plates? 2°. Will an electric current precipitate gold from a cyanide solution? H. B. C.

1°. No dynamo will furnish current to accomplish the object desired. 2°. An electric current will not precipitate gold from any solution, though it may deposit gold from a solution on a cathode.

What is specific inductive capacity? G. K.

The specific inductive capacity of a dielectric substance is the measure of its effect on the capacity of a condenser when used to separate the two sides. Air being taken as unity, when the sides are separated by paraffine, ebonite, gutta-percha and flint gas, the capacity of a condenser is increased as (approximately) 2, 3, 4 and 7 respectively.

Can Thomson recording wattmeters be changed for use on other voltages than that for which they are rated? C. B. L.

Yes, by putting in a new armature adapted to the voltage, using a rheostat, also adapted to the voltage, in series with the armature, and a new shunt field coil of the proper strength. The capacity of the meter will be increased if the voltage is higher than originally.

1°. For a physician's use, would you recommend the induction coil in preference to the influence machine for Röntgen-ray work? 2°. Which is the better insulation for induction coils; air, oil or paraffine? W. H. H.

1°. The induction coil is preferable on account of cost, reliability and simplicity of operation. 2°. The resistance to sparking in air is less than in the two other substances named. Oil is inferior to solid paraffine for the reason that convective discharges take place in the former.

Some builders wind field coils on tin or galvanized-iron spools slotted lengthwise, claiming that this prevents heating. Is there any advantage in this? T. B.

In machines like the Brush and T.-H., which generate fluctuating currents, there may be some advantage. In true direct-current machines it is a disadvantage, as the slotting can do no good when the fields are charged, and when the field circuit is broken a closed spool circuit would tend to reduce the extra current.

What change would be necessary to adapt the small motors described in the February and April numbers, to a 500-volt circuit? A. G.

For the drum-armature machine, make the armature coils of No. 30 wire, as many turns per coil as possible. Wind the field with No. 34 wire, 47 layers deep, 234 turns long. For the ring-armature machines, wind armature same as above. Wind field coils with No. 34 wire, 24 layers deep and as long as space will allow.

How can I change a No. 14 G. E. street-car motor into a compound-wound motor? H. C. J.

Note the amperes in field when running normally, and count the series turns, from which the ampere-turns will be determined. Wind the field with wire of such a size that its resistance will allow a current to pass which, multiplied by the turns, will give the above ampere-turns. (See AMERICAN ELECTRICIAN, March, 1897, p. 98, for full directions.)

I rewound a G. E. 800 motor armature and when testing it on a car found that when the reversing lever was thrown to "ahead," the car shot back. What is the explanation? J. H. S.

You probably led the winding in the opposite direction to the original winding. For example, if the original winding brought the ending of a series of coils to the commutator bar on the *left* of the one connected to the starting end, your final end was carried to the bar on the *right* of the starting end; or *vice versa*.

How may a cell be made of wood for storage batteries? W. S. T.

Take six parts burgundy pitch, one part old gutta-percha in small pieces and three parts rotten-stone. Melt the gutta-percha, knead with the rotten stone and then add the melted pitch. Use a hot smoothing or soldering iron to smooth the surface and heat the material so that it will enter the pores of the wood. The wood should be well dried and preferably warmed before applying the mixture.

Why are the brushes of a four-pole motor placed 90 degs. apart, instead of 180? M. S.

Because of the arrangement of the winding. There are two distinct generating circuits in a four-pole machine, one corresponding to one pair of adjacent poles and the other to the other pair; as in the case of a bipolar machine, the position of the brushes for each circuit is between the poles, which brings the brushes 90 degs. apart. Instead, however, of using four brushes, the two circuits are connected in parallel, thus reducing the brushes to two.

What is a polyphase current? A. B. K.

There is no such thing as a polyphase *current*; polyphased *currents* are two or more alternating currents differing in phase. The currents possess no peculiarities in virtue of differing in phase, being nothing more than common alternating currents such as are generated by the ordinary "single-phase" alternator. Their value lies in the fact that when, for example, the three currents of a three-phase circuit are passed through the windings of a field magnet with three-polar projection—one current to each pole—the poles have different magnetic strengths at any one instant of time, which causes the magnetic field exterior to the poles to rotate as the currents change in value.

What should be the winding of the primary of a 6-in. induction coil for a 110-volt circuit? H. M.

A single layer of, say, No. 12 or 14 wire. In the circuit external to the primary use as many 16-CP lamps in parallel as will pass the largest current in the coil that will not overheat it. The ideal winding for an induction coil is a single-turn, with sufficient current to give the necessary ampere-turns; the reason being that in order to get a quick-break, and therefore high secondary E. M. F., the circuit should have a minimum inductance. If lamps are not used, the resistance wire in the exterior circuit should be wound non-inductively—that is, not in a coil, but zig-zagged with the parallel lengths close together. Under no considerations should many turns of wire be placed in the primary merely to supply resistance. In fact, the primary of an induction should be the same for a battery or a 500-volt current, any resistance necessary being non-inductive and placed in the exterior circuit.

New Apparatus and Appliances.

A SMOOTH-RUNNING ISOLATED PLANT.

The accompanying illustrations refer to an isolated lighting plant recently installed under conditions somewhat exceptional in character. The plant was put in by the firm of J. Manz & Company, engravers, Chicago, to be used for driving their power plant, lighting the workshops and generating the necessary current required in their business. After due consideration, the Ideal engine, manufactured by A. L. Ide & Sons, Springfield, Ill., was purchased, on account of the many superior features which this engine possesses, including reliability and smooth running. The unit consists of a 13 in. × 12 in. latest type of Ideal engine, located on the seventh floor of the building, and the purchaser was given a guarantee that when carrying its rated capacity it would operate noiselessly and without vibrating or shaking the building, or causing any annoyance to the tenants of the building.

The method of securing this engine originated with the builders, and will be readily understood from Fig. 2, shown on next page. The engine is located as close to the wall as is possible. This wall is about 2 ft. thick, and a small casting with a face 21 ins. long is secured to it by a 1¼ in. bolt. On the face of this casting are placed two girders or T-rails, which are bricked into the wall and bolted to same. These bolts extend through a clamp 1½ ins. thick by 3 ft. 6 ins. high and are securely fastened. The girders extend the entire length of the engine sub-base, and are located so that the bottom edge is 6 ins. above the floor line. After the engine was located in its proper position, two ⅞ in. bolts were off-set and connected with two eye-bolts, extending through the brick wall, and connected to the engine by means of an eye-bolt securely fastened to the engine frame. The tension on the bolts, that is, between the eye-bolts in the wall and eye-bolt on top of the engines, is governed by means of a swivel nut. When in position, the distance between the eye-bolts in the wall is about 6 ft.

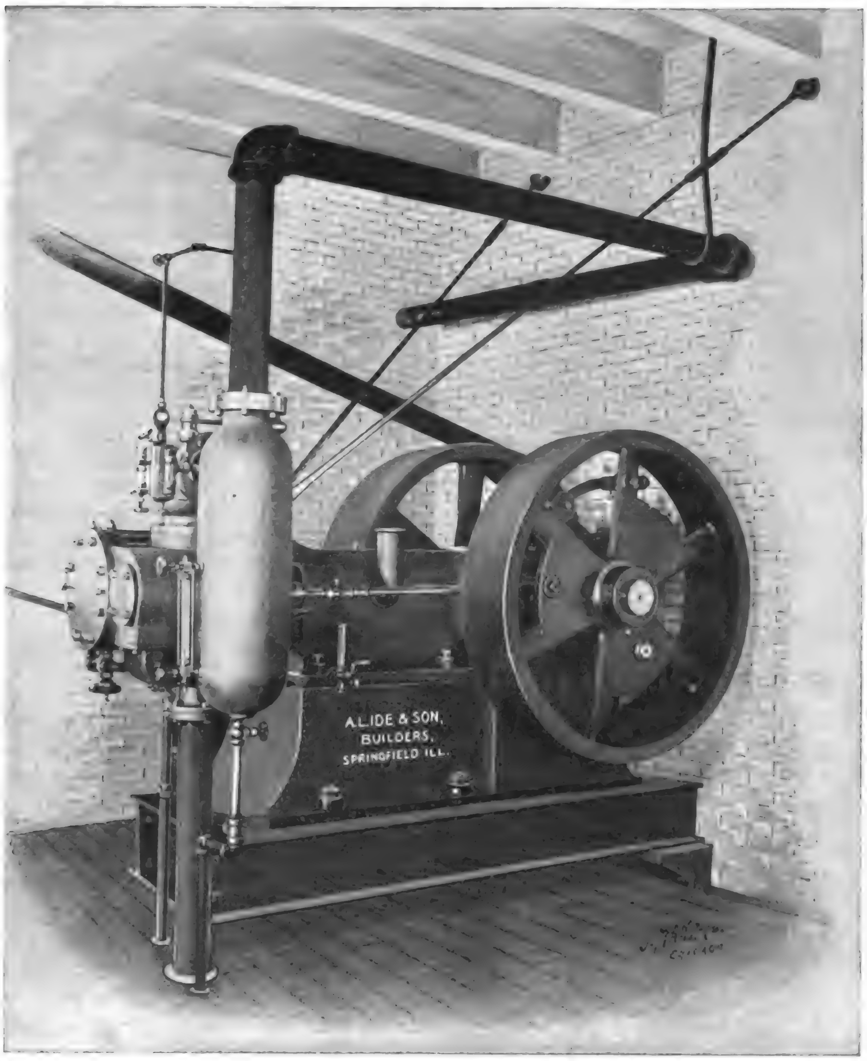


FIG. 1.—SMOOTH RUNNING ISOLATED PLANT.

The steam used for driving the engine is generated in the basement of the building, and to protect the engine from water it is equipped with an Ideal steam separator of the latest improved type. The engine is balanced so perfectly that when in operation and carrying its rated load there is not a particle of vibration, and the tenants on the floor below do not know when the engine is in operation or when it is shut down, so noiseless is its operation. The power is transmitted from the engine by a 14-in. belt to a counter-shaft, and the counter-shaft is connected to a main shaft by another 14-in. belt. There is a friction clutch on this counter-shaft, so that the engine can be thrown into service or cut out at any time desired. There is also a 40-KW latest improved National Electric multipolar dynamo connected to the main line shaft operated by this engine.

THE SMITH-VASSAR TELEPHONE SYSTEM.

In the October number an account of the Smith-Vassar telephone system was given in its general features, and we illustrate herewith one of the instruments.

When it is desired to call up a subscriber, a plug is placed in a hole of the switch-board shown, the hole plugged corresponding to the number of the subscriber called; the handle is then turned until arrested by the plug; finally, the telephone is taken from the hook, following which two actions occur:

First, by means of simple mechanism in the uppermost compartment, an idle line wire is selected. For example, if there are ten wires supplying one hundred subscribers, and six of these, corresponding to the first six contacts, are "busy," the "selector" contact arm passes over these and stops at the seventh contact, thereby cutting into circuit the corresponding line wire (or pair of wires); the circuit between the two stations is thus completed and cannot be cut into by any other telephone.

SMITH-VASSAR TELEPHONE SYSTEM.

Second, by means of a contact cylinder in the middle compartment, connection is formed through to the desired subscriber. If, for example, he is ten stations distant

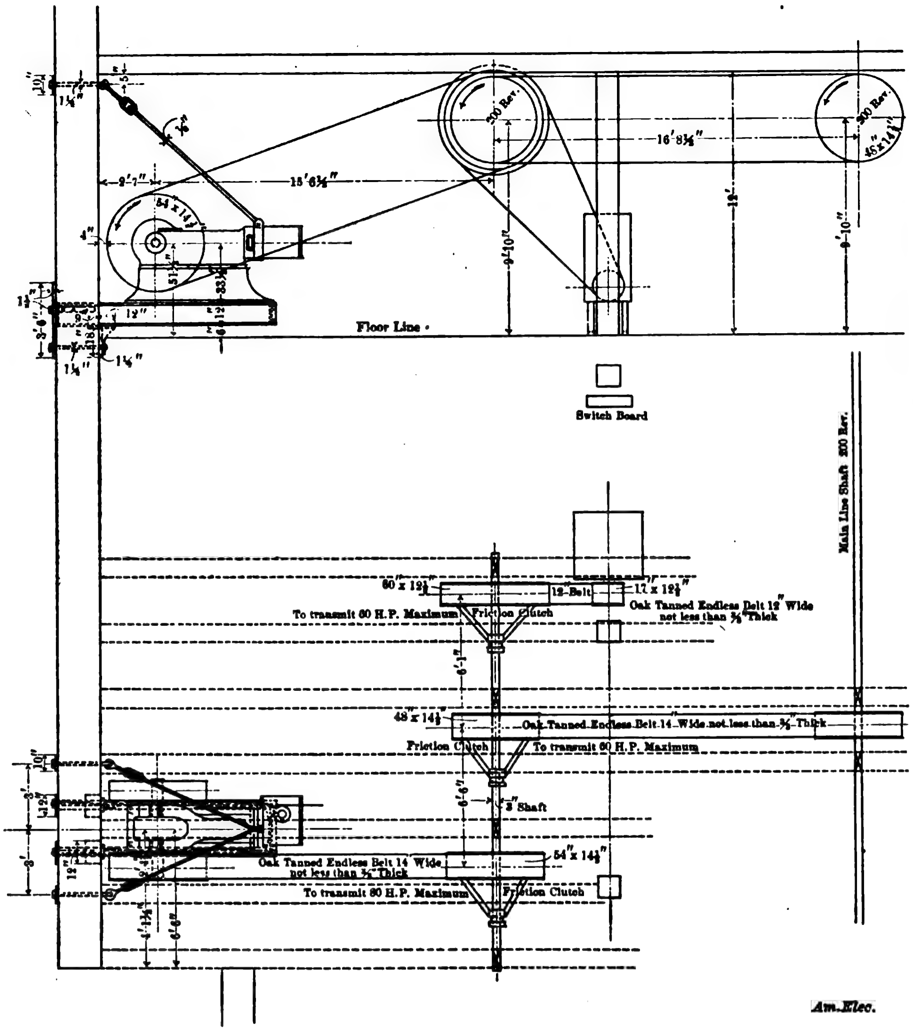


FIG. 2.—SMOOTH RUNNING ISOLATED PLANT.

from the calling station, an electromagnet at each of the intervening stations cuts in the section of line between it and the next station, such sections being cut in successively until the desired station is reached and signaled; whereupon the calling devices at all the instruments that have operated are instantly returned to normal position.

While the conversation is taking place between two stations, any other station can call another and establish connection in the same manner as above described, and still others can do the same until all the idle wires (or pairs of wires), are occupied. The moment any pair of correspondents hang up their telephones, the wire (or pair of wires), they have used becomes idle and open to be used by any others.

The Smith-Vassar Telephone Company is now giving a complete illustration of its system in its offices, Lord's Court Building, New York City.

STAR SOLDERING STICK.

The Western Electric Company is placing upon the market a soldering stick, the general appearance of which is shown in the accompanying illustration. The stick is about 6 ins. long and ⅜ in. in diameter. It is composed of carefully prepared and pure chemicals which are non-corrosive and at the same time make a very superior flux for soldering.

The virtue of this stick is that it makes the solder adhere to the wire, and all well posted electricians understand how important it is that the solder should unite with the wire in making a joint. If there is a gap between the solder and the wire and the two metals do not amalgamate, there is a local action caused by the current of electricity which eventually will eat away the wire at the joint. It is for this reason that the underwriters have been so particular to specify that joints shall be well cleansed and soldered, knowing that a joint that is not cleansed could not be well soldered and would be a hazard from the fire-insurance standpoint. For this reason the wireman will appreciate a soldering stick possessing the qualifications of the one above mentioned.

STAR SOLDERING STICK.

KEYSTONE SWITCH-BOARD INSTRUMENTS.

The cut herewith gives a general idea of the shape and character of scale of a new line of switch-board, potential and current indicators designed to meet the class of trade requiring accurate and durable instruments at low prices. The instruments are mounted in a tastefully designed case, finished in oxidized copper and well lacquered. The moving parts are mounted in jewelled bearings, the cases are dust-proof, and the instruments are not affected by external magnetism or changes of temperature.

SWITCH-BOARD POTENTIAL INDICATOR.

While the prices at which these instruments are offered is low, it is claimed that none of the essential features of a thoroughly reliable instrument have been in any way slighted. The manufacturers are the Keystone Electrical Instrument Company, Philadelphia.

SINGLE-CYLINDER BALL ENGINE.

A record of many years of unqualified success, and its many electric-light and electric-railway stations in all sections of this country, makes it unnecessary to introduce to our readers the "Ball" engine, built by the Ball Engine Company, Erie, Pa. Its friends, however, will be pleased to see some new features which well merit their attention.

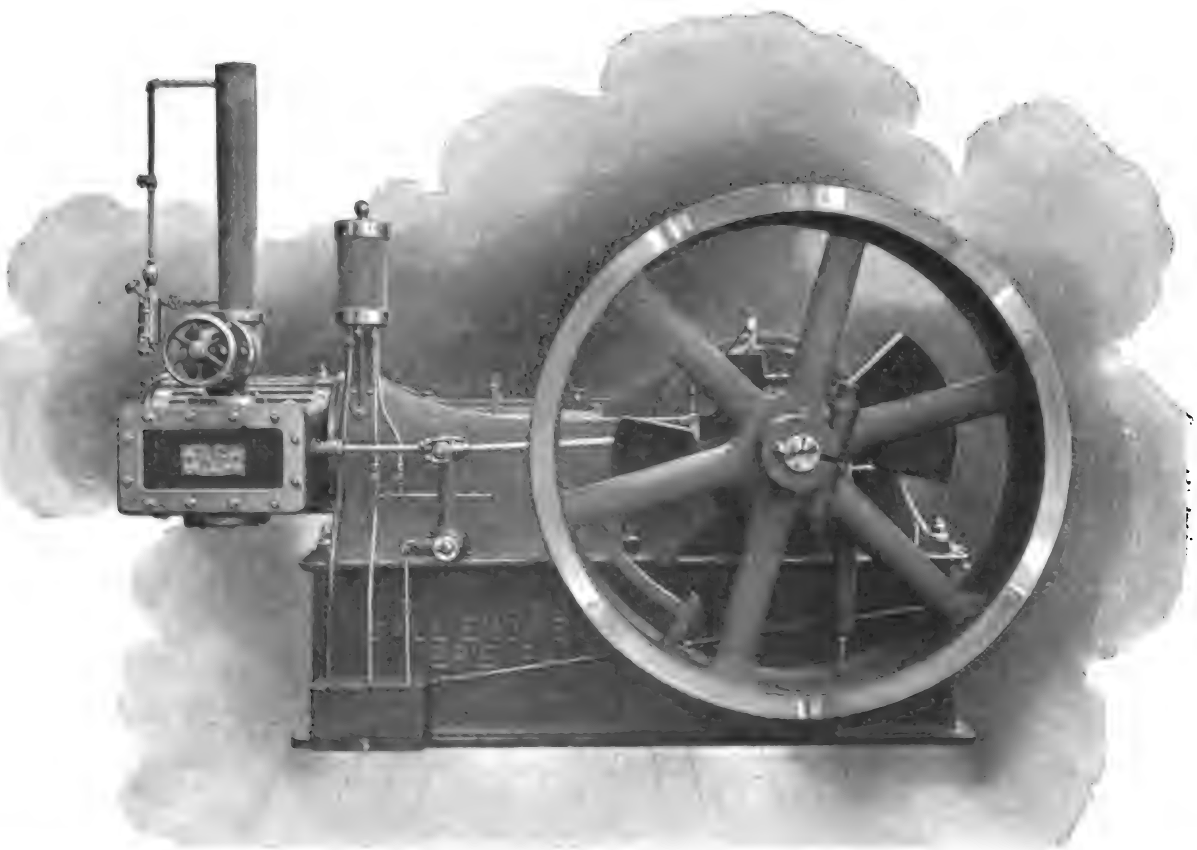
The single-cylinder engine, as illustrated herewith, is equipped with the new Rites governor and automatic lubricating system, and presents a very pleasing appearance. The governor, which was fully described on page 374 of our September issue, is a combination of inertia and contrifugal forces, and not only regulates to the very highest degree of perfection, but with an extraordinarily rapid adjustment, and without the slightest degree of instability or racing. It also has the advantage of great simplicity, as the entire governor consists of but a single moving piece suspended upon one pivotal point, thereby reducing friction to a minimum.

The lubrication of the engine, as illustrated, is accomplished by the use of the gravity system of supply to graduated sight-

feeders located at the various oiling points upon the engine. This system becomes automatic through the use of a pump that is driven continuously from the valve motion, delivering oil into the tank. The pipes are so connected that direct pressure may be established on the supply pipes for the purpose of removing any obstruction that may occur.

The gravity system of oiling seems to have many advantageous over the splash or direct forcing system, for in these systems, in the process of elevating the oil to a sufficient height to feed over the engine, the oil becomes aerated, but in the gravity system by pumping into a tank there is opportunity for the air to leave the oil; consequently each of the feeds shows clear oil, instead of oil that is almost saponified by being filled with air.

The oil after having been distributed over the running surfaces, gravitates down to the bottom of the inside of the frame, and from there is led out to the front end of the frame and through an inclined pipe down to a receiving tank setting near the floor level. Here the oil passes through one or two screens to remove any floating particles of foreign matter, and is then pumped to the supply tank above the engine in a much greater quantity than is called for to supply the engine, the surplus being carried back to the receiving tank by an overflow pipe. This arrangement insures an absolute flood



NEW BALL ENGINE.

of oil, if desirable, over the engine, as well as a supply of oil for the engine for a long run without the use of the pump.

COMBINATION LAMP GUARD.

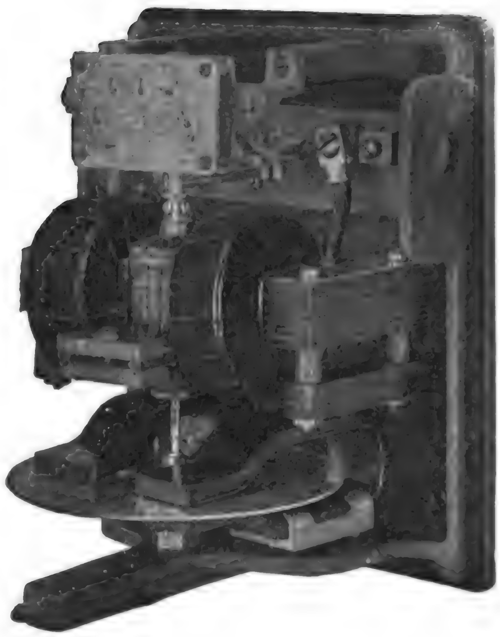
The combination lamp guard shown herewith is made to fit any type of socket, and is manufactured in brass or tinned iron. The socket is very easily placed in position and so constructed as to offer a firm resistance to any ordinary shock, thereby giving efficient protection to a lamp. The appearance of the guard, as will be seen from the

COMBINATION LAMP GUARD.

engraving, is much more graceful than the older types. The guard is made by Scott Brothers Electric Company, Detroit, Mich.

RECORDING WATTMETERS FOR STREET CARS.

The adoption of more careful and accurate methods in street railway work is typical of the universal struggle for economy. The advantage of exact measurement of station output has long been recognized, and the requisite meters provided, but to record the ever-varying energy used on a car traveling over all conditions of road, involves difficulties almost unsurmountable. In the Thomson recording wattmeter for street railway service, however, the General Electric Company claims to have overcome all the obstacles. The new meter which has been placed on the market after a number of years of experimental work, is intended for installation in the car, like a car register. It re-



INTERIOR OF CAR WATTMETER.

cords the actual energy used by the car. A few trials determine the proper energy consumption per car per trip under various conditions of track and traffic. Subsequent readings of the meter determine at once if energy is carelessly wasted, and thus serve as an effectual check on the motorman and condition of the motors.

The use of street car meters will mean a saving of 10 per cent. of the total energy generated. The profit from such economy

is twofold. It saves, first, the cost of coal and water necessary to generate one-tenth of the total output of the station, and second, it increases the receipts by increasing the car capacity without enlarging the station, or, in other words, enables the station manager to operate 10 per cent. more cars without increase in the station equipment.

The simple motor construction of the car meter, as shown in the accompanying illustration, is similar to that of the other forms of Thomson recording wattmeter, but new conditions imposed by the rough service have been met by the careful design of the rotating parts. Unavoidable vibration, due to rough tracks, demand a low drop in the armature in order that contacts may not be injured by sparking. High torque is also a requirement so that heavy brush pressure, insuring perfect contact, may be used. The sudden and wide variation of current requires a meter that will start quickly and slow down as soon as the current diminishes. The General Electric Company claims high accuracy for its new car meter and ability to withstand severe and continued use on the roughest tracks. The meter is now made for 500-volt circuits in sizes for 25 or 50 amperes with a liberal provision for overloading.

A RENOVATED STORAGE BATTERY.

In our July issue we printed an article describing the overhauling of the Palmer House storage-battery plant at Chicago, Ill., by Mr. J. E. Haschke, which battery was refitted with his electro-chemically prepared

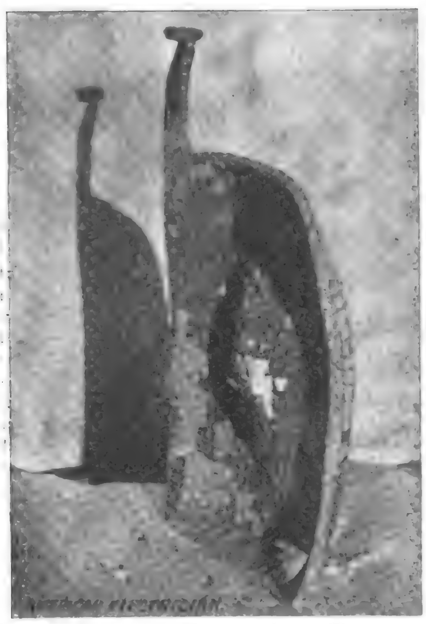


FIG. 1.—ONE OF THE OLD PLATES

insulation. This plant is reported to be in excellent condition. For the benefit of our readers, Mr. Haschke furnishes us the following description of the overhauling of another plant, which may prove of interest to those interested in accumulators.

About two years ago, a plant of fifty-eight cells of storage battery of 100 ampere-hours capacity, was installed at the West Side Brewery Company's brewery, at Chicago, Ill. This battery was composed of three negative and four positive plates to each cell. The accompanying cut illustrates the appearance of one of the outside positive plates which had only one side exposed to chemical action. A battery in this condition could not stand the strain of being transformed, as the outside positives were ready to fall or disintegrate. The only insulation was strips of glass about 10 ins. long, 1 in. wide and $\frac{1}{4}$ in. thick; consequently the cells buckled and were useless in a very short time. The cells were then left alone for about two years; the solution evaporated, the active material fell from the plates and the plant was considered a mass of junk.

A few months ago all the positive plates and part of the negative plates in this battery were repasted and overhauled by the

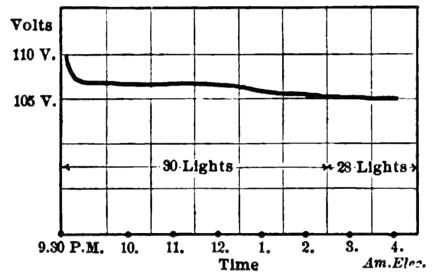


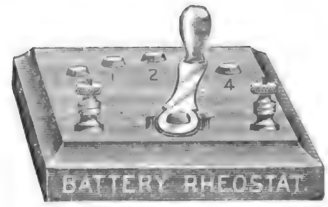
FIG. 2.—CURVES OF DISCHARGE.

Haschke system, the same as in the case of the Palmer House plant. The above curve shows its efficiency under a rate of discharge greater than normal.

Each positive plate in this battery was enveloped in a single sheet of Haschke insulation and the mass tightly banded together, the plates being separated about $\frac{1}{8}$ in., which reduced the internal resistance considerably. It is claimed that a large amount of circulation of electrolyte is not necessary between the plates, as the chemical properties of this insulation are claimed to assist the chemical action of the cell, thereby allowing a high and constant voltage during the discharge. Further information on this subject can be had by addressing Mr. J. E. Haschke at his laboratory, corner Ogden Avenue and Ashland Boulevard, Chicago, Ill.

BATTERY-CURRENT REGULATOR.

The battery-current regulator shown herewith will be especially appreciated by the student and amateur experimenter in connection with experiments on small lamps, motors, etc. When the lever is at the extreme left point, the circuit is open; when at 1 the circuit is closed with no resistance introduced; at 2, $\frac{2}{3}$ ohm is cut in, at 3, $1\frac{1}{3}$ ohms and at 4, 2 ohms. The resistance material used is fully protected from injury, and thus will last indefinitely. The rheostats are neat and handsome in appear-



BATTERY RHEOSTAT.

ance, the metal parts being nickel-plated and mounted on a thick polished oak base. M. R. Rodrigues, 17 Whipple Street, Brooklyn, is the manufacturer.

ALTERNATING-CURRENT SWITCHBOARDS.

Of the switches used by the General Electric Company upon the alternating-cur-

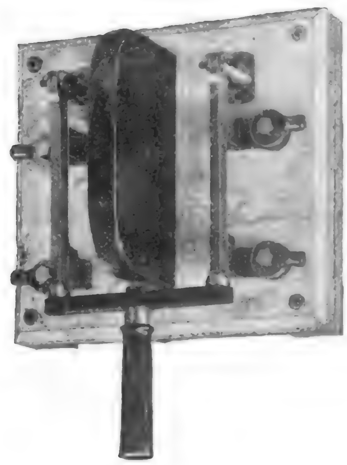


FIG. 1.—BARRIER SWITCH.

rent switch-boards manufactured at its works in Schenectady, one is the double-break switch (Fig. 1) commonly called T.-H. This has recently been improved by placing barriers between the blades, making it satisfactory for use on circuits with a potential up to 2300 volts.

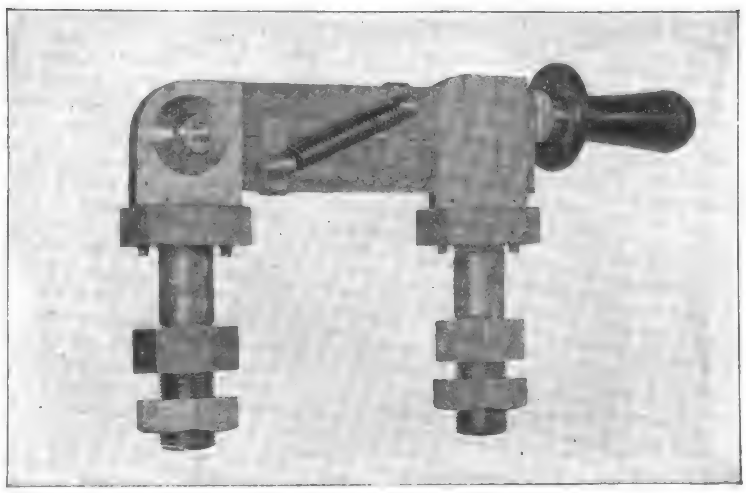


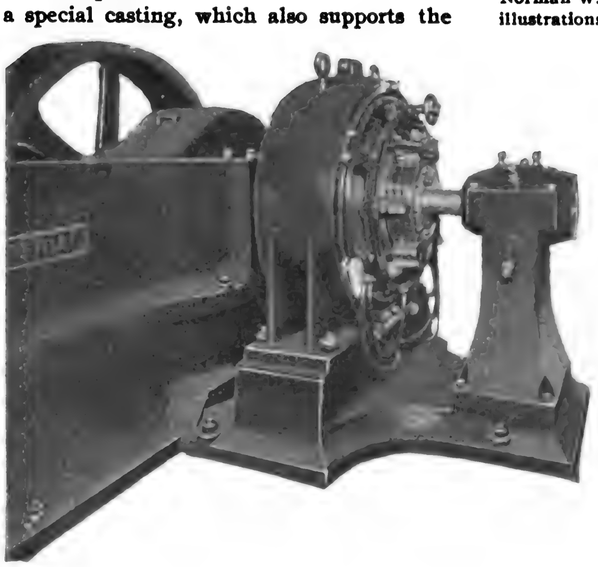
FIG. 2.—QUICK-BREAK SWITCH.

The quick-break switches (Fig. 2) for use on circuits of nominal 500 volts, also manufactured by this company, are constructed with a view to obtain the greatest accuracy. The switch-blade contact consists of two

pieces laid edge to edge, and connected to a common hinge. They are also connected by a pair of spiral springs, one on each side. Both sections of the blade make connection with the contact clip. In opening the switch, the outer section of the blade, to which the insulated handle is attached, is withdrawn to an angle of 30 degs. before the inner section moves. The inner half of the blade then begins to move, forced from the clip by positive action; as it leaves the clip it is drawn smartly up to the outer half of the blade by the action of the tension springs. The result is an extremely quick break and a wide gap, over which an arc cannot hold. Switches of this type are made in capacities from 50 to 5000 amperes at 750 volts, are constructed for both single and double throw, with or without bases, with either front or back connections, except with the 1800-, 3600- and 5000-ampere switches, which are not furnished with bases unless on special order.

DIRECT-CONNECTED GENERATOR.

The accompanying illustration shows a late type of direct-connected generator, built in sizes from 7½ to 150 KW. The various sizes of these machines are designed to work at the highest commercial efficiency at various speeds. The armature is carried on a special casting, which also supports the



DIRECT-CONNECTED GENERATOR.

commutator and is easily applied to and removed from the engine shaft. The armature windings are of bar copper and are retained in position without the use of binding wires. The field magnets are laminated and split vertically, thus making it possible to remove them without the use of overhead tackle. The machines are sparkless between full and low load, and are designed to carry a safe overload of not less than 25 per cent. Mica is used throughout for insulation, both in the armature and commutator. This machine is made by the Fisher Electrical Manufacturing Company, of Detroit, Mich.

PERSONALS.

Mr. A. McNab Little has accepted a position as traveling salesman for the Western Electric Company, of Chicago.

Mr. W. W. Griscom, whose death by accident recently occurred, was connected with the electrical industry from its earliest days. He was perhaps the first to develop the electric motor, the Griscom sewing-machine motor having had a great sale long before the full possibilities of the electric motor in general were suspected. In recent years Mr. Griscom devoted himself to the storage battery and made a number of valuable contributions to the literature of the subject.

Mr. A. L Ide, senior partner of the firm of A. L. Ide & Company, engine manufacturers, of Springfield, Ill., whose death occurred Sept. 29, is a great loss to both the engineering profession and the manufacturing industry. One of the first to take up the manufacture of automatic engines, he ceaselessly devoted himself to the advancement of steam engineering. He was a pioneer in several of its branches, and at the time of his death had just put into commercial shape several improvements to the steam engine.

Mr. George E. Pratt, late secretary and general manager of the Hunt Air-Brake Company, of Pittsburgh, Pa., has severed his connection with that concern and entered the service of the Standard Air-Brake Company as special agent. Mr. Pratt has been an earnest worker in the air-brake field, and as he thoroughly believes in air-brakes, has decided to continue in the business. We predict for him a long and successful career in this field, and his hosts of friends will doubtless be interested on learning of this new connection. It is certain that Mr. Wessels is surrounding himself with the best representative men in the various branches of the company's business.

NEW BOOKS.

STANDARD ELECTRICAL DICTIONARY. By T. O'Conor Sloane. Second edition. New York: Norman W. Henley & Company. 682 pages, 393 illustrations. Price, $3.

The preface of the second edition of this excellent dictionary is dated September, 1897, and states that the text has been brought up to date, including the new terms introduced by the great discovery of Röntgen. An admirable feature is the very complete index, which includes all synonymous words and terms. This obviates the necessity of too-frequent cross references in the text, which only occur when attention is directed to other subjects having a direct relation to that under definition. Another commendable feature consists in quotations from authorities on important, obscure, or contested points of electrical science. It is to be regretted that the author made an exception in defining electricity by not adducing accepted authorities; of the 17 quotations under this head but one—S. P. Thompson—can in any sense be considered a modern authority, and he merely gives a working hypothesis. Lodge, Kelvin, Thomson, Rowland, Helmholtz, Hertz and others of high authority have expressed themselves on this subject, and if these instead had been quoted, the reader would not be left with the fallacious idea that electricity is more mysterious than such other manifestations of nature, as heat, light, gravitation, etc.

ELECTRO-DYNAMIC MACHINERY FOR CONTINUOUS CURRENTS. By Edwin J. Houston, Ph. D. (Princeton) and A. E. Kennelly, Sc. D. New York: The W. J. Johnston Company. 331 pages, 232 illustrations. Price, $2.50.

Among the many elementary treatises on the principles entering into the design and operation of continuous-current machinery, this easily ranks first as an easily read and, at the same time, accurate work. The treatment is thorough without being more detailed than its plan as an elementary work warrants. The chapters on magnetic flux and the magnetic circuit are especially valuable, the accompanying numerical examples thoroughly illustrating the principles developed. As a reliable, clearly written and logically arranged introduction to the theory of electrical machinery, this book can be confidently recommended to the student. While for its reading an elementary knowledge of algebra is desirable, this is by no means necessary, as mathematics appear in the book only incidentally and even then but rarely.

TRADE PUBLICATIONS.

Platinum. In an artistic little pamphlet, Baker & Company, Newark, N. J., give an interesting account of the sources of supply, the identification and separation of platinum ore. An illustration shows the largest nugget of platinum, now in possession of Baker & Company, ever found on this continent.

Telephones. The eighth edition, just issued, of the catalogue of telephones, telephone and electrical supplies, of DeVeau & Company, 32 Frankfort Street, New York, contains 64 pages, mostly devoted to telephone apparatus, including parts of transmitters, such as carbon backs, balls, diaphragms, etc.

Porcelain Insulators. C. J. Kemble, 7 Arch Street, Boston, in a lately issued pamphlet describes and illustrates the different types of "Imperial" porcelain insulators. Considerable information is given concerning the properties of porcelain that make that material so superior for insulating purposes.

The Midnight Sun. With this title the Jandus Electric Company, Cleveland, O., has issued an artistic pamphlet in which users of arc lamps will find much of interest. Besides describing and illustrating in full detail the Jandus enclosed-arc lamp, an interesting comparison, accompanied by curves, is given of the distribution of light from enclosed and open arcs.

Motor Starters. Thos. Muir & Son, 31 Larned Street, Detroit, Mich., describe in a circular their several types of automatic motor starters, applicable to pumps, organs, cranes, fans, elevators, etc. Among the advantages claimed for the Muir motor starters is that the reversing switch cannot be thrown without first opening the main switch and setting the rheostat arm back to normal.

Shaking and Dumping Grate Bars. James L. Robertson & Sons, 68 Cortlandt Street, have issued an attractive pamphlet of interest to all steam users, describing in detail the Robertson shaking and and dumping grate bars. Mention of other Robertson specialties is incidentally included, and in a manner which should prove of interest to catalogue writers, who are referred to the pamphlet for details.

Motor Starting Apparatus. The Automatic Switch Company, Equitable Building, Baltimore, Md., has issued a new catalogue which contains illustrations and descriptions of two new pieces of apparatus of its manufacture—a non-magnetic automatic starter and a quick-acting switch. The first-mentioned piece of apparatus is much simplified through the absence of dash-pots, solenoids, magnets and latches.

Shallenberger Meters. One of the handsomest trade pamphlets of the year has been issued by the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., devoted to the standard type of Shallenberger meters which it manufactures. The meter is well illustrated in detail, and the somewhat recondite theory of its action clearly explained. Some pages are given up to a catechism, which brings out the superiority of meter over flat rates, and gives other useful information.

Walker Monographs. The three most recent Walker circulars (Nos. 1053-4-5,) are devoted to electric railway subjects. One gives a thorough technical account, written by Mr. George A. Damon, of the Englewood & Chicago storage battery road; another illustrates and describes in full detail the latest type of Walker motor; and the third gives the decision in full of the Circuit Court of the United States, District of Massachusetts, dismissing a suit alleging infringement in the Walker method of motor suspension.

Keystone Generators and Motors. The Keystone Electric Company, of Erie, Pa., and the Dispatch Printing & Engraving Company, of the same city, are to be congratulated upon the artistic appearance of a catalogue just issued by the former company, describing its new line of direct-current multipolar generators and motors. The engravings are excellent and show in minute detail every part of the machines described, while in paper, printing and cover the pamphlet ranks with the best examples of metropolitan work.

Art in Advertising. The Western Electric Company, Chicago, has its imprint on a colored engraving of the highest artistic excellence, entitled "Full Measure and Good Quality." A strawberry

box, with part of its contents spilled on a white napkin, is shown, and the coloring of the berries is wonderfully true to nature. The engraving is printed on cardboard, and is well worth framing. The reverse side has some matter relating to enclosed arc lamps; to those interested in such lamps, a copy of the engraving will be sent on application.

BUSINESS NEWS.

A Correction. In a business news note in the October issue relating to recent contracts of the Standard Air-Brake Company, it should have been stated that sixty air-brake outfits had been ordered from a British colony, and not *six*, as printed.

The Eddy Electric Manufacturing Company, Windsor, Conn., is experiencing a gratifying increase of business, having been running its works from 6:30 A. M. to 9 P. M. for several weeks, in order to keep up with orders.

The Electric Arc Light Company, manufacturer of the Pioneer enclosed arc lamp has moved its office to the American Tract Society Building, 150 Nassau Street. Mr. W. C. Hubbard has been elected secretary of the company.

Renewing Incandescent Lamps. The Gilmore Electric Manufacturing Company, 625 First Street, South Boston, finds its business of renewing lamps has grown to such an extent as to make it necessary to duplicate all the machinery in the lamp department.

The Philadelphia Electrical Manufacturing Company, 2110 Jones Street, Philadelphia, is very busy filling orders for its line of cut-outs and arc-lighting supplies. The business of this company has grown to such an extent that it is about to double its factory facilities.

Wiring Tables. "Wiring Tables: How They Are Made and how to Use Them," a book published by Mr. Thos. G. Grier in the spring of this year, has nearly reached a circulation of 1000 copies, which speaks well for a book of a technical nature which has been out such a short time.

Dynamo Brushes. Chas. Wirt, 1028 Filbert Street, Philadelphia, manufacturer of the well known Wirt dynamo brushes and testing instruments, is receiving numerous letters from users of his brushes, giving very flattering testimonies as to their durability and efficiency and reliability under trying conditions.

The Long-Burning, Enclosed Arc Lamp. The long-burning, enclosed arc lamp, manufactured by the Western Electric Company, is attracting considerable attention among the central-station men who are operating direct-current plants, owing to the peculiar shape of the globe, which gives a beautifully uniform distribution of light.

Telegraph Manual. The Western Electric Company has published a telegraph manual and book on batteries which is for use among amateur electricians, but is of value to practical men as well. This manual is only given out on receipt of ten cents, and boys interested in the study of electricity would do well to enclose ten cents to the Western Electric Company and obtain a copy of this valuable little book.

Electrical Supplies and Fittings. Scott Brothers Electric Company, Fort and Shelby Streets, Detroit, Mich., is placing on the market a new type of combination lamp guard having many superior features. The same firm also manufactures fuse links for Edison and Sawyer-Man cut-outs and a very efficient commutator. In addition, it carries a stock of motors and dynamos and is agent for the Sawyer-Man lamps.

The Puritan Electric Company, formerly of 150 Nassau Street, New York, has moved its office to the Bowling Green Building, 11 Broadway, New York, where it has increased facilities for handling the alternating, enclosed arc lamp of its manufacture. This change was rendered necessary by the large increase in business which has developed since the fall season has commenced, and which has taxed its facilities of production to the utmost.

Battery Table Lamps. The Ohio Electric Works, Cleveland, first introduced the successful necktie light, then the bicycle electric light with primary battery, the carriage light with dry batteries, and now is introducing a battery table lamp at a popular price, and dealers can obtain exclusive sale by applying early for agencies. The new catalogue for 1898 is now ready for distribution, and a copy will be mailed to any one who mentions this paper.

Electrical Exhibition. The Electrical Exhibition Company has closed a lease for the Madison Square Garden Building, for the Electrical & Kindred Industries Exhibition, to be held in May, 1898. The amphitheatre, with arena circles, concert hall, assembly hall, nd machinery hall in the basement, afford a total of over 100,000 sq. ft. of floor space—considerably more and better adapted space for the purpose than at the Central Palace exhibition in 1896.

Woven-Wire Brushes. Goldmark & Wallace, 29 Chambers Street, New York, announce a reduction in the price of Koch woven-wire dynamo brushes without tubes, which were formerly sold at the same price as the brushes with tubes, on which latter there has been no change. The object of the tubes in Koch brushes is to stiffen them sufficiently to allow them to be used without guards. Where guards are not objectionable, Koch brushes can be supplied without tubes at reduced prices.

The Book of the Royal Blue. Among the many advertising novelties soon to be issued by the B. & O., is one which is sure to attract a very considerable amount of attention. It is to be known as "The Book of The Royal Blue" and is to be issued monthly by Col. D. B. Martin, manager of passenger traffic. Of magazine size and filled with attractive half-tone illustrations and good reading matter, "The Book of The Royal Blue" is sure to make a hit. One feature is a list of names and addresses of every passenger and freight agent.

The General Incandescent Arc Light Company, New York. Owing to the unexpected increase in volume of the enclosed arc-lamp business, and in view of greater convenience to its customers, has decided to open a down-town office in New York, instead of handling business entirely from the factory as heretofore. Offices have accordingly been opened in Bowling Green Building, 11 Broadway, and placed in charge of Mr. Fred. E. Dolbier as manager of the arc-lamp sales department, to which office all orders and inquiries for arc lamps should be sent.

Mr. Frank E. Fisher, of the Fisher Electrical Mfg. Co., Detroit, Mich., to a recent inquiry, "How is business?" from a representative of the AMERICAN ELECTRICIAN, replied, "Well, just tell them there is a decided improvement, but we haven't started our plant running all night as yet. During the last two months, however, every machine in stock has been sold out and the demand for new apparatus is good. We have just completed a 700-light installation in the Whitney Opera House, and we are about to install a 1500-light plant for the Newcomb & Endicott Company, the largest dry goods house in the city, besides several less important installations."

New Pullman Line to Washington and Baltimore. The Monon Route has established a new thorough sleeping-car line between Chicago and Washington and Baltimore via Cincinnati, the C. H. & D., B. & O. S. W. and B. & O. railways. The sleeper is ready for occupancy in Dearborn Station at 9:30 P. M., and leaves at 2:45 A. M. daily, arriving at Washington at 6:47 and Baltimore 7:55, the following morning. As the sleeper goes through without change, and as the hours of leaving and arriving are so convenient, this will prove altogether the most comfortable, as well as the most picturesque, route to the national capital. Chicago city ticket office is 232 Clark Street.

Metropolitan Electric Company. Mr. Wm. H. McKinlock announces that Mr. John McKinlock has purchased the stock, property and good will of the Metropolitan Electric Company. Messrs. Wm. H. McKinlock and W. C. Camp will act as agents for the disposal of this stock and will take other business in the general electric line as carried on heretofore by the Metropolitan Electric Company. The mammoth catalogue of the Metropolitan Electric Company will be available to those who will send one dollar for the express charges, or a small order to pay for the transportation of same. This catalogue is the most remarkable of its kind ever published, being the largest and most complete, and every one should have a copy.

They Look Ahead. It seems strange when one is thinking of getting out a heavy overcoat and preparing for the chill of winter to visit a place where the main subject of conversation is how to keep cool. If one should, however, visit the Western Electric Company's factory, he would see fan motors for desks, for ceilings and for walls in preparation for the warm season of next year. The smooth running and economical operation of the Western Electric fans placed them at once in the front rank of fan motors last year, and the difficulty was, not to sell them, but to keep up with the orders. To avoid any disappointment to customers, they are making ample preparations to meet the rush of business next spring and summer.

Arc Lamp Windlass. The Ayers self-locking arc-lamp windlass is not a new article and is reasonably well known to the trade. It has not, however, received the attention as a specialty which an article of this kind needs to get it properly before the buying public. The Electric Appliance Company, of Chicago, however, has recently taken up this article as a leader, which is a guarantee of the fact that the trade will become better acquainted with it. The Ayers windless is simple and durable, being built to stand the wear and tear of rough work. It is also sold at a price which is a good deal of an inducement, and a great many of them should be placed this fall and winter. The only safe method of suspending lamps is the windless arrangement, which is a little more expensive on the start, but is the cheapest plan in the long run.

Telephones. Among the many Western concerns which have felt the wave of prosperity is the Farr Telephone & Construction Supply Company, 342 Dearborn Street, Chicago, which has received more than its share of telephone orders and supplies, particularly within the last two months. While this is due, to a large extent, to the company's energetic management, the excellent reputation its goods have earned is no doubt responsible in a large measure for the largely increased business. The company has received orders from all parts of the United States and, in addition, from many foreign countries. The catalogue and hand-book of information, which the Farr Company is willing to send to anyone on request, has met with great favor among telephone users, as it contains much useful information for those desiring to put up telephones.

The C. & C. Company. While all the different electrical manufacturing companies now seem far busier than for several years past, there are several of them which appear to be exceptionally busy, among them being the C. & C. Electric Company, whose general offices are in New York, at 142 Liberty Street. Its large works located at Garwood, N. J., just out of New York, present a very busy aspect just now, where a large force of skilled men are working both day and night in an effort to promptly fill the vast number of orders which have come to the C. & C. Company this fall, partly as a result of the general business improvement, but mainly owing to the remarkable favor its several new lines of apparatus have met with. The C. & C. Company reports a splendid demand for its enclosed type slow-speed ironclad motors to be used in all classes of work as well as for its new "M. P." dynamos for direct and belt service

The Pierce & Miller Engineering Company, reports a strongly marked increase along all its lines of business, following the return of its president, F. M. Pierce, from his tour around the world, during which he made many valuable connections. From observations made while abroad, he decided that America would do a large European business in furnishing equipments for electric tramways, and to accommodate this and the rapidly increasing home trade, a large increase in this company's engineering and selling force has been drawn from England and Ireland. Mr. Pierce has made strong financial connections in London and New York, which enables his company to "finance" electric railway and other first-class enterprises. This company reports work in hand as follows: one 300, three 1200, three 800 HP, and several hundred horse power in small engines, and one complete railway power plant. This company is now handling the Rice-Sargent engine for large work, and the "Standard Ball of Erie for the small, high and medium speed, electric purposes.

Commutator Compound. K. McLennan & Company, sole manufacturers of the celebrated "Gale's Commutator Compound," for absolutely preventing sparking and cutting of commutators, putting a high gloss on the commutator without gumming the brushes, stated to a representative of this paper recently that the sales of their compound had increased more than three-fold since Sept. 1; that at the present time the compound was regularly used

by every power plant and central station in the United States and Canada, and by a vast number of isolated plants. They stated further that the reduction in price of their compound had helped to increase sales. They have recently established agencies in Norway, Sweden, England, France, Germany, and have in course of completion an agency in Japan. "Nearly all of this foreign business is due to advertising," stated Mr. Isaacs, manager of the company, "and we invite the readers of the AMERICAN ELECTRICIAN, who have not yet tried this compound, to ask their supply house for a free sample stick, or to write to us at the office, Marquette Building, Chicago."

CONVENTION NOTES.

The Chicago Insulated Wire Company was represented by Mr. W. R. Smith.

The Bibber-White Company, of Boston, was represented by Mr. Chas. E. Bibber.

The Washington Carbon Company, of Pittsburgh, was represented by Mr. J. S. Crider.

The Okonite Company was well represented by one of its officers, Capt. W. L. Candee.

The Safety Insulated Wire Company had its interest well taken care of by Mr. Harry Richards.

Hope Electric Appliance Company, of Providence, had an exhibit of switches and cut-outs in charge of Mr. J. T. Drake.

The Buckeye Electric Company, Cleveland, O., had its interests looked after by Mr. Bailey Whipple.

The Standard Paint Company, New York, in Mr. J. C. Shainwald, had an able exponent of P. & B. compounds.

The Jandus Electric Company, Cleveland, O., had an exhibit of Jandus enclosed arc lamps in charge of Mr. Bailey Whipple.

The Lombard Water-Wheel Governor Company, Boston, had its interests in charge of Messrs. Allan V. Garratt and H. M. Daggett.

Mr. John T. McRoy, Chicago, looked out for the interests of his conduit system, and distributed some cleverly written advertising literature.

The Solar Carbon & Manufacturing Company, Pittsburgh, had Messrs. F. M Laughlin and H. E. Webb on the ground to look after its interests.

Messrs. L. A. Chase & Company, Boston, were represented by Mr. Sears B. Condit, who gave information concerning their new type of railway circuit breaker.

W. R. Brixey, New York, and "Kerite" products were ably represented by Mr. Geo. F. Porter, secretary of the National Electric Light Association, and Mr. F. S. Fuller.

The Weston Electrical Instrument Company, Newark, N. J., was much in evidence from the number of its instruments used in connection with exhibits of other companies.

D. & W. Fuse Company, of Providence, R. I., was represented by Mr. L. W. Downes, one of the inventors of the enclosed wire fuse and an authority on fusible cut-outs in general.

Mr. Luther Stelreager, without whom an electrical gathering would appear lonesome, was present, and much consulted by railway managers as to traffic-increasing attractions in the way of electrical illuminations.

The Storey Motor Company, Philadelphia, was represented by its genial and popular president, Mr. I. E. Storey, who renewed many acquaintances and found few who did not know of the Storey iron-clad motor.

Fred. Locke, Victor, N. Y., represented by Mr. C. E. Greene, exhibited a complete line of his justly famous insulators. Many were doubtless surprised at the massiveness of the insulators for high alternating potentials.

The American Electrical Works, Providence, R.I., had its interests looked after by Messrs. P. C. Ackerman, F. B. Baker and F. E. Donohoe, who distributed a souvenir in the shape of a letter weight made of wire similar to that used on the Buffalo-Niagara transmission line.

The Central Electric Company, Chicago, represented by Messrs. W. R. Garton and H. E. Adams, showed a line of Sterling electric railway supplies and material, including commutator bars, overhead material, etc. The G rton lightning arrester was a prominent part of the exhibit.

The Cutter Electric & Manufacturing Company, of Philadelphia, had an exhibit of magnetic circuit breakers that attracted much attention, one of the circuit breakers shown having a capacity of 3000 amperes on a 220-volt circuit. Messrs. H. B. Kirkland and W. M. Scott were in charge.

The Sterling Supply & Manufacturing Company, New York, was represented by Messrs. F. A. Morrell, L. E. Roberts and William Tiffany, and showed a large variety of electric railway specialties and supplies. A souvenir distributed by these gentlemen consisted of a handsome combined clock and paper weight.

Mr. E. O. Sessions, Portsmouth, N. H., engineer of Frank Jones' electrical department (which includes four electric railways), was an interested visitor to the convention. One of the early engineers in the electrical field, the Niagara gathering enabled Mr. Sessions to renew some old-time acquaintances.

The General Incandescent Arc Light Company, represented by Mr. E. A. Lavins, had a working exhibit of its well-known types of arc lamps, including the General Incandescent enclosed arcs, four of which are operated in series on an electric railway circuit. A line of switches was also shown, and types of Bergmann voltmeters.

Morris, Tasker & Company, Philadelphia, had as a representative Mr. C. Y. Flanders, whose exceptionally large acquaintance among street railway men was evident from the numerous greetings he received after the arrival of each detachment. A souvenir n the form of a purse with transparent sides, also made Mr. Flanders in much demand.

The Fuel Economizer Company, represented by Mr. P. J. Challen, had on exhibition a model of the Green economizer, which is being more and more largely adopted as an adjunct to power and central-station and generating plants. Those fortunate enough to be on hand while the supply lasted were presented with a handsome souvenir card case.

The Standard Thermometer & Electric Company, Peabody, Mass., had a full display of the new Upton "Midget" enclosed arc lamp, as well as complete lines of its other lamps. The first mentioned lamp reduces to five the number that can be burned on a single series line across an electric railway circuit. Mr. M. L. Livingston was the representative present.

The Keystone Electrical Instrument Company, of Philadelphia, represented by Mr. J. F. Stephens, had an attractive exhibit of switch-board instruments, including the new type of potential and current indicators described on another page. The exhibition switch board had an added interest from the fact that the wood-work was from material obtained from the rafters of the house in which Thomas Jefferson drew up the Declaration of Independence.

The J. G. Brill Company had on the ground a staff, consisting of Messrs. John A. Brill, Edward Brill, W. E. Partridge, W. H. Archer, .M. Haskell, W. H. Hastings and M. Curwin. The exhibits of this company, indoor and outdoor, were naturally among the most conspicuous at the convention, and embraced everything relating to trucks and their details. A much-sought-for souvenir distributed by this company was a Cox computer for electric traction problems.

The Joseph Dixon Crucible Company, Jersey City, represented by Mr J. H. Baird and A. L. House, distributed several pencil souvenirs, one being of mammoth proportions, and another of miniature cross-section. Among the materials on exhibit that attracted particular attention was a lubricating compound for gears, consisting of a mixture of graphite, wood pulp and grease. Besides being a first-class lubricant, its use conduces to noiseless running of gears.

The Electric Storage Battery Company, Philadelphi , was represented by General Manager Herbert Lloyd and Messrs. Chas. Blizard, J. B. Entz, J. Y. Bradbury and F. H. Clark. Its exhibit in the hall was an instructive one, consisting of a storage-battery working equipment by means of which, in connection with the necessary switches and measuring instruments, the useful function of a battery in taking care of electric railway fluctuations of current, was made clearly evident.

The Mica Insulator Company, of New York, was represented by Vice-President Franklin Brooks and Mr. Charles E. Coleman. The exhibit was completely representative of mica insulation as applied in the electric railway industry, and as such served as an object lesson of much interest to visitors. Pure mica, micanite and a new mica compound, known as the "M. I. C. compound" were shown in every size and shape, the latter making its début at the Niagara convention.

The Peckham Motor Truck & Wheel Company, New York had a staff in attendance consisting of Messrs. Edgar Peckham, J. E. Long, A. W. Field, W. H. Gray, J. A. Hanna, and Charles Ackley. In and about the exhibition building were shown Peckham motor trucks of different types, and in the Peckham parlor headquarters at the International Hotel were some extremely handsome motor-truck models, constructed principally of aluminum. Those directly interested in electric railway equipment were presented with expensively bound copies of motor truck literature.

The Westinghouse Electric & Manufacturing Company occupied a large space in the exhibition hall with a complete line of its electric railway equipments. The central object was a booster outfit consisting of a compound-wound motor driving a 300-HP, series-wound generator. Surrounding this were railway motors complete and in detail, switch-board equipments, line lightning arresters, etc. Messrs. W. F. Zimmerman, E. H. Heinrichs, R. D. Brown, T. C. Frenyear, C. A. Bragg, J. R. Gordon, Maurice Coster and W. K. Dunlap, with Messrs. Storer, Mallet, McLaren and Siegfried from the factory, were in attendance.

The Standard Air-Brake Company, New York, was represented by General Manager E. J. Wessels, Col. C. B. Fairchild and Messrs. H. B. Taylor, E. H. Dewson, Geo. E. Pratt and E. E. Robinson. The main feature of its exhibit was a working electric railway air-brake equipment. The visitor could see the operation of every part of the system, including the action of the brake, the automatic starting up of the motor to renew the air pressure, the automatic provision for the case when current is interrupted while the motor is in operation, etc. All of the different forms of Standard axle-driven compressors were also shown. This exhibit was the most instructive of any in the hall from an educational standpoint, and attracted much attention.

The Walker Company, had a large space for its exhibit of electric-railway apparatus, which included a 400-HP elevated-railway motor mounted on a truck. The latest type of Walker controller attracted much favorable attention, and a crowd was always gathered about a model showing the working of the new type of magnetic blow-out with which the controller is fitted. The latter consists of solenoids embedded in the partitions between the contact fingers, thus being not only in the most favorable position, but occupying no additional space. The company was represented by Prof. S. H. Short, Mr. F. W. Ferguson, Mr. H. McL. Harding and Messrs. Chas. N. Black, W. A. Johnson, Daniel D. Craft, J. Holt Gates, B. M. Barr, Henry G. Issertel, William Gibbs Bain, J. S. Anthony, Chas. E. Bibber, Alex. T. Moore and R. H. Gay.

The General Electric Company occupied the principal parlor at the convention hotel and a large space in the exhibition hall. The motor exhibit consisted of a half dozen or more different types of electric railway, motors, some mounted and shown in motion. Armature construction was exemplified by an exhibit representing all of the details. Three switchboards showed different apparatus, one being devoted to circuit breakers, another to electrostatic ground detectors, wattmeters, etc., and the third to lightning arresters. The exhibition space was illuminated by a number of General Electric enclosed long-burning arc lamps. At the headquarters parlor was an X-ray booth in which exhibitions were given to invited guests. The interests of the company were cared for by Mr. W. J. Clark, general manager of the railway department; W. B. Potter, chief engineer and Messrs. Ralph H. Beach, L. D. Tandy, J. G. Barry, Lee H. Parker, F. E Case; W. G. Carey, E. D. Priest, F. M. Poyles, H. Kernochan, Edgar Carolan, J. R. Lovejoy, H. C. Wirt, J. H. Aitken, C. D. Haskins, F. M. Kimball, T. Beran, A. D. Page, W. G. Bushnell, A. B. Shepard, T. P. Baily, E. D. Mullen, W. J. Crowley, C. C. Pierce, W. F. Hayes, F. B. Strieby, S. W. Trawick, A. C. Tenny, F. F. Barbour, Geo. D. Rosenthal, T. H. Fearey, D. F. Potter and Irving Hale.

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A PRACTICAL APPLICATION OF ELECTRIC HEATING

IN every case where an electric current flows through a conducting medium, there is a transformation of electrical into heat energy. When lighting or power is the desired effect, the heat produced becomes a necessary evil and enters into the losses of transformation. It is only within comparatively recent years that the other extreme has found extensive commercial application.

The utilization of the electric current for the production of useful heating effects presents a number of peculiar features probably absent in almost any other transformation. Primarily, such change is theoretically free from losses, and the efficiency, therefore, of the utilized heat energy with respect to supplied electrical energy depends simply on the methods adopted for absorbing the heat energy generated. The efficiency would be 100 per cent. were this completed. This consideration is certainly highly important as long as electrical energy is costly. Other reasons, however, are perhaps even more potent in developing the various possibilities of electric heating.

We find, for instance, a field of vast possibilities in the application of abnormally high temperatures, in the production of which the electric arc and its modifications

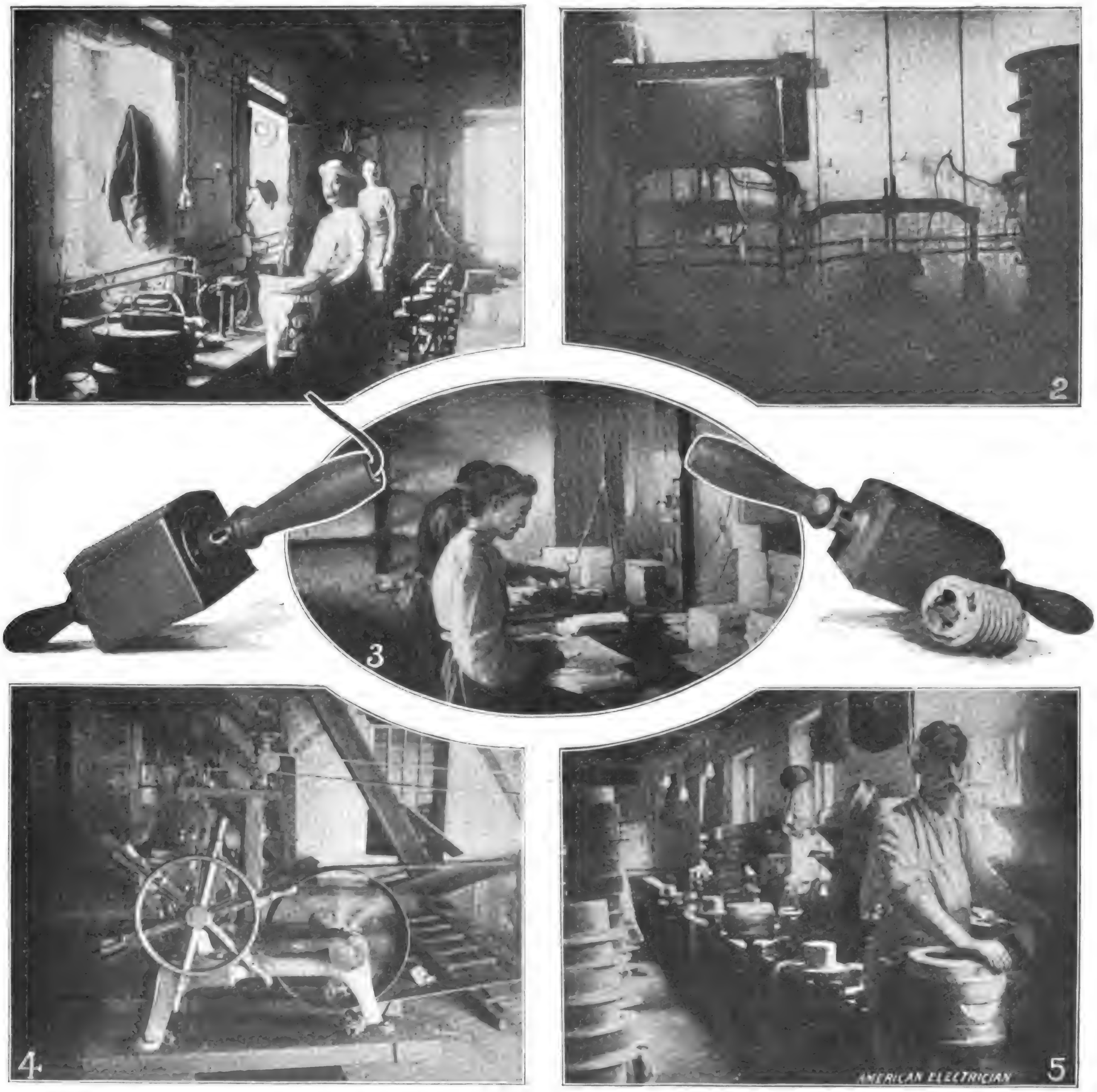


FIG. 1.—LARGE FLAT-IRON. FIG. 3.—SMALL SAD IRON FOR TIPPING. FIG. 2.—ELECTRICALLY HEATED PRESS HEAD.
FIG. 4.—WATER WHEEL GOVERNOR. FIG. 5.—ELECTRICALLY HEATED HATTER'S FLATS.

ELECTRICITY IN A HAT FACTORY.

stand supreme. Metallurgy has received a most wonderful impetus since the value of this application has been appreciated, and the production of new materials, already due to it, gives promise of great results for the future. When, however, lower temperatures find utilization the more direct resistance transformations are adopted. The fact that a conducting resistance can be made to conform to almost any shape or size, and concentrated to any degree with the greatest ease, gives electric heating of this type a peculiar advantage. When to this are added the multitude of other obvious advantages, it will readily be appreciated that when in actual competition with gas for similar concentrated, medium high temperature work, electricity has no difficulty in proving its superiority.

Straw hat manufacture affords many opportunities for the application of heated ironing and pressing devices, both manual and power. Hand hat-irons, flat irons, presses, and small stoves and glue pots are amongst the apparatus usually heated by gas.

The large straw hat factories of Wm. Carroll & Company, located at Matteawan, N. Y., were formerly equipped for gas heating. Men's, women's and children's straw hats are manufactured here throughout the year, and an operative force of nearly 500 men and women is employed, producing a daily output of 600 dozen hats, at times increased to 750—800 dozen.

It was decided some time ago to substitute electrically heated appliances for the present gas machines, and with this object in view the present equipment, which is to be extended in the future, was gradually installed with most satistactory results. The peculiar conditions which by all means warrant such an installation in this particular case are notable.

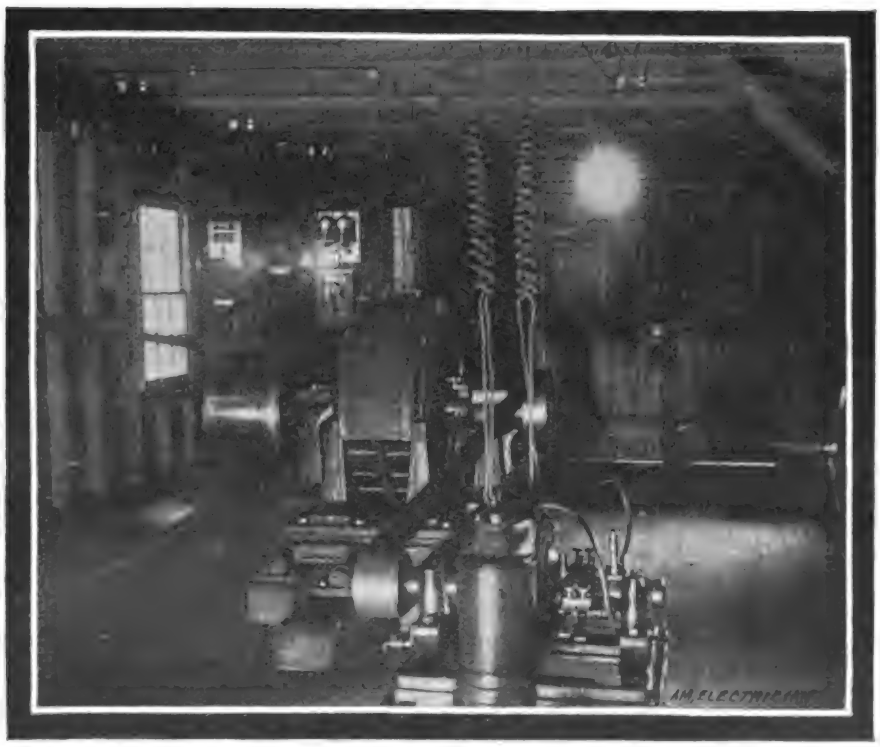


FIG. 6.—GENERATING ROOM.

The factory buildings are located on the Fishkill Creek about 1½ miles from the Fishkill Landing Station of the N. Y. C. & H. R. R. R. Fishkill Creek, emptying into the Hudson River, has for many years furnished power to the manufacturing establishments on its banks. The creek is dammed some distance from its outlet into the river. As the factory is located about a mile away from the dam a long flume supplies the 42-in. Leffel turbine under 29 ft. head which, during almost the entire year, operates the factory. A 150-HP Fishkill-Corliss engine is held in reserve for periods of low water.

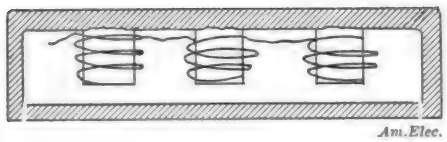


FIG. 7.—CROSS-SECTION OF ELECTRIC STOVE.

About two years ago an electrical equipment was installed. Previously an isolated gas plant supplied all gas for lighting and heating. In order to make the electric plant available as an auxiliary supply service to the alternating current station service of the Carroll Electric Company, located some distance from the factory, an alternating generator is used. This machine furnished by the United Electric Improvement Company resembles a Ferranti alternator. It has two sets of circularly placed, horizontally directed, field magnets, between which the armature revolves. A unique feature is the entire absence of iron in the armature construction. A separate Manchester type direct-current exciter is belted to the dynamo shaft. The generator operates at 650 r. p. m., has 24 poles and is of 1000-light capacity. A Replogle electric water wheel governor controls the turbine inlet gates.

Adjacent to the dynamo is a skeleton switch-board, on which the main and throw-over switches and instruments are located. The dynamo generates current at 1000 volts, which is applied to converters placed in the dynamo room and elsewhere, from which 104-volt secondary circuits extend throughout the factory buildings.

All interior wires are run on porcelain insulators or cleats, and supply about 500 incandescent 16-CP lamps, a number of 300-CP lamps and the electric heating appliances, which were furnished by W. S. Hadaway, Jr. These heating devices include about twenty special hatters' flats, fifteen large and small flat irons, ten circular flat stoves 8 ins. in diameter, six glue pots and a number of special press heads. Altogether when in operation these present appliances consume a total of about 20 KW of electrical energy. As ordinarily used, however, the current is switched on and off of the various irons, etc., and the average current consumption must then be considered. Actual experience has shown that this total is about 50 per cent. of the figure given. It is this feature which gives electrically heated devices of this nature a peculiar advantage, scarcely obtainable with gas or with any other heating medium.

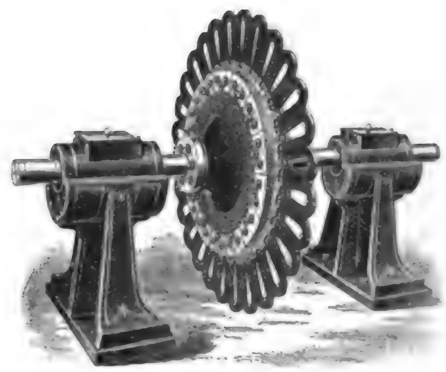


FIG. 8.—ARMATURE OF ALTERNATOR.

In the construction of the heating apparatus special attention has been paid to operative life. Bare Krupp resistance wire is used, enclosed in the exterior casing in a manner which experience has shown gives a minimum deterioration.

The hatters' flats shown in the illustration consist of an iron block almost square in cross-section and about 6 ins. in length, and with handles at each end. One end of this casing is removable and the heating resistance is inserted at this end. This resistance consists of a long spiral of Krupp wire wound on a central insulated core which, with its wire, is rigidly held in the casing. Operating on 104 volts, these irons take about 5 amperes each when running constantly. They are used to iron the crown and brims of straw hats, as shown in the illustration.

In the stoves and some of the flat irons, the wire is placed around inwardly projecting plugs (Fig. 7), forming part of the outer casing. It is held in position and insulated by a special cement. The large flat irons are about 11 ins. long and weigh about 15 lbs. They are used for ironing the upper side of the hat brims.

The small irons find a very unique application. In order to cement the silk name band to the lace lining, a small piece of rubber is laid between them, and the heated iron is then touched to the lace over the rubber,

thereby melting it and cementing the two parts.

As glue is required in very large quantities, the glue pots find continuous use. Instead of keeping the working current of 2½ amperes on the glue pot resistance, however, these are only heated at the beginning and the glue kept at the desired temperature on the small stove. The glue pots are of the usual double receptacle form, the outer water jacket holding a copper tube heating coil, inside of which, properly insulated, the resistance wire is placed.

Electrically heated dies and press heads are to be substituted for the present gas heated devices used in the hydraulic and hand presses for forming and pressing various parts together. Two hydraulic presses are already so equipped. These presses are used to finish the hat crown, at the same time fastening the glued paper lace and name ribbon to the inside. The hat is put on a block and the circular electrically heated head is brought down upon it, accomplishing all in one operation. The present press heads take 8 amperes when heated. It is expected that similiar applications will materially increase the ease, comfort and economy of the other operations in the course of manufacture.

Amongst other apparatus a number of electrically heated power ironing machines are now being built. It is also expected to eventually substitute motors for the present method of driving, particularly in the out buildings.

As the main consideration in an installation of this nature is the comparative economy of operation aside from all others, this feature is of particular value, as it shows a decided saving in favor of the electrically heated appliances. Previous to the installation of the electric plant gas was manufactured on the premises at a cost of from $1000 to $1200 per year. The output then did not exceed 400 dozen hats per day. Now, with almost double this capacity and an increased lighting service, the total cost for electrical service does not exceed $200 per year. This result is certainly primarily due to the water power plant and consequent low cost of power supply; but even with steam power the advantage have been shown to be decidedly in favor of electric lighting and heating.

An interesting feature in connection with this plant is the fact that practically the same firm, under the name of the Carroll Electric Company, operates the electric light and power central station serving Matteawan, Fishkill Landing and Fishkill-on-Hudson. The plant is also located on the Fishkill Creek and is operated by water power with a steam reserve.

The electrical machinery includes Heisler series incandescent, United Electrical Improvement Company's alternating, General Electric power and Schuyler arc dynamos. The service includes lighting and stationary and electric railway power supply. A feeder connects the station with the isolated plant, and the latter can be used as an auxiliary after the factory working time. This combination of electricity and hat making is unique, particularly when it is considered that the same executive successfully manages both.

ON METHODS OF TESTING ENGINE GOVERNING.

BY F. W. ROLLER, M. E.

The important point in the governors of steam engines for electric work, more particularly in the case of those used for direct connection, is not that they shall merely be capable of keeping the engine running at the same speed whether fully loaded or light, but that they shall make the readjustment of their parts when the load changes, practically instantaneously, in order that the voltage of the dynamo operated may not fluctuate noticeably and affect the lights.

In order that a governor may operate at all, it is of course necessary that the speed should first change, so as to give the centrifugal force, gravity or inertia, whichever may be utilized, an opportunity to exert itself. The amount of variation in speed required, however, should be a minimum, and, still more important, the action should be "dead-beat" so that the parts do not swing past the position corresponding to the new load and have to return to it again, giving the phenomenon known as "hunting." The question of designing so as to cover these points will not be taken up here, but methods of testing to show how well they are fulfilled in any given case will be described.

The methods may broadly be divided into two classes, the first giving visual indications only, from which the amount and time of the speed variations may be computed, and the second, which gives permanent records. The first are, generally speaking, the simpler.

The one of this class most commonly used is by employing a tachometer. This instrument consists briefly of a heavy disk of metal mounted by pivots on a shaft in such a manner that its plane cuts the shaft axis obliquely. When the shaft revolves, the disk tends to place itself so that its plane is normal to the shaft axis, as in this position its center of gravity is at a maximum distance therefrom. This tendency is opposed by a spring.

A system of levers communicates the disk motion to a hand moving over a dial, which is calibrated by marking the positions that the hand takes when the shaft is revolved at known speeds from an outside source.

It can now be seen that if we connect the shaft of the instrument with that of the engine under test, the speed at which the latter is at that time revolving is shown. When then the engine speed changes and, say falls off preparatory to the governor's readjusting itself, the shaft of the tachometer also slows down and the same force no longer being exerted by the disk to place itself normal, the spring draws it down to make a lesser angle with the shaft axis, and this is shown on the dial by a movement of the hand. When the governor admits more steam and brings the speed back to the proper point, the reverse of this action takes place and the needle indicates the original speed. The time therefore that it takes for the needle to go from normal down and back again is taken as an indication of the time that the engine has been running too slow and the amount of falling off to show the amount of falling off of the engine speed.

Unfortunately, however, the indications are anything but accurate. The disk inertia, which is necessarily considerable, has to be overcome before the spring can act, the numerous parts give many chances for friction and lost motion, and the strength of the spring may vary from temperature, age, magnetization and other causes. Further, the tachometer shaft is either driven by a belt, in which there is change of slippage on change of speed or by friction from the engine shaft, in which case the spiral spring, always interposed by the makers between the point of their shaft and that of the engine, will allow considerable give.

The tachometer movement has been utilized to make a recording instrument by substituting a slightly different system of levers so as to give a movement of the hand through a small arc of a circle only and substituting for the hand an arm carrying a pencil point whose movements were recorded on a revolving drum. In this the engine and instrument shafts were rigidly connected so as to do away with the last source of error mentioned, but even then it was found by comparison with records simultaneously taken by the accurate tuning-fork chronograph described later, that the device could not be depended on within 5, and, in some cases, as high as 10 per cent. We see from all the above, therefore, that the tachometer method is practically valueless.

A second method, perfectly accurate, but more difficult to apply in ordinary tests, is as follows: On the edge of the engine fly-wheel is put a mark, say, of white paint; the room in which it stands is partially darkened and across a pair of spark gaps placed opposite the wheel, sparks are passed at a known rate which is so chosen that their number and that of the revolutions of the engine per minute at normal speed are equal. It follows from this that at a constant engine speed, the sparks will pass each instant when the white mark is in the same position, and that it will therefore, on account of the extremely short duration of the spark, seem to remain constant in that position. If now the engine speed slackens off, the spark rate remaining the same, at each revolution the white spot will be lit up at an earlier period than the one preceding, and it will hence appear to the eye to be revolving backward at a rate per minute equal to the rate of drop in the speed of the engine. Inversely, if the engine runs faster the spot will seem to travel ahead. It will be seen that the results are beautifully clear and distinct.

To get the sparks at the proper intervals—a somewhat difficult matter—the most certain method is to drive a make-and-break wheel by a motor running on a source of constant potential or by a very heavy fly-wheel driven by a light and slack belt at a high rate of speed from the engine itself. The latter is simpler and is found to run at a speed sufficiently close to absolute constancy in practice to properly drive the break wheel when the engine governor is at all well designed although it may be still further steadied by the interposition of some form of flexible coupling between its pulley and the fly-wheel,

The sparks should preferably be obtained direct by the interruption of a circuit taken from some large source of supply such as a storage battery or a set of regular lighting mains with a resistance, say, a bank of lamps interposed. The contacts on the break-wheel should of course be easily removable and of cheap material. A different and very ingenious source of light has been proposed but not to the writer's knowledge ever actually tried, which is to use an alternating lamp in place of the sparking arrangement noted, fed from an alternating source of a constant and known frequency, preferably, of course, an even multiple of the engine speed.

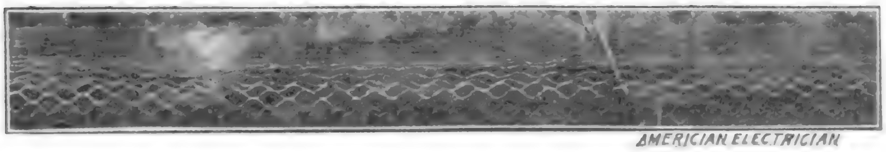


FIG. 1.—CHRONOGRAPH RECORD.

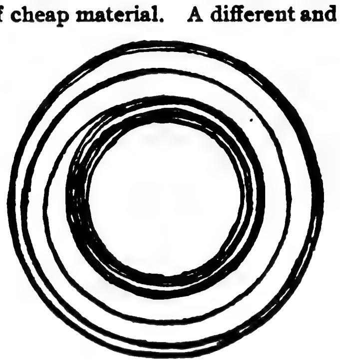


FIG. 2.—ECCENTRIC CARD.

A tuning-fork control has also been spoken of.

Method number three has been proposed innumerable times by different parties and consists in driving a small armature direct from the engine shaft in a field formed by carefully-aged permanent magnets and reading the voltage variation due to changes in speed on a highly sensitive and dead-beat galvanometer of the d'Arsonval type, the value of whose deflections would be calibrated directly in revolutions by comparison with a known source. If this device was thoroughly iron-clad so as to be shielded from the stray fields which often exist in direct-connected units, this should give most excellent results.

Coming now to the class of devices that give permanent records, we have, first and foremost the tuning-fork chronograph which may be described as follows: Driven direct from the engine shaft there is a light drum of any convenient length and diameter whose surface is covered with paper heavily blackened with soot from a smoky lamp.

Fed across on a coarse screw parallel to the axis of this is a block carrying a large tuning-fork which is guided by a pin so that it can be depressed till it nearly touches the paper and at the same time allows it to be raised a considerable distance. A stiff bristle or a piece of wire is fastened to one of the legs of the fork by sealing-wax and the whole then set in vibration by a blow or by an electro-magnetic device. From the nature of a tuning fork the rate of its vibrations is, of course, constant, their amplitude only being subject to variation with the increase or diminution of the exciting force.

The drum being already in motion, if we now depress the fork till the bristle point touches the paper and at the same time feed it longitudinally by the screw, there will be traced on the drum a wavy line winding spiraly about it.

When the paper is removed and cut open we have a flat sheet with undulatory lines thereon, through which neutral lines may be drawn midway between the upper and lower wave crests. The wave lengths measured on these lines will be constant for a constant engine speed, but will, of course, decrease as the speed decreases, and increase as it increases.

From the known vibration-rate of the fork and the length of the record paper, which equals the circumference of the drum, we can compute not only the speed in revolutions per minute during any given revolution, but even the rate at any portion of the revolution represented by a single wave length. This method has the merit of absolute accuracy, it is easy to apply and compute from, but has the disadvantage that the record of a few revolutions only can be made at one time and that the drum has to be disconnected each time to remove and replace the paper. An illustration of the record obtained by a very crudely made chronograph on the above basis is given herewith in Fig. 1. Here the fork was stationary and the drum pushed along its shaft from which it was driven by a feather, by hand. Instead of paper covering the drum, the soot was deposited directly on it, and the record traced was transferred by rolling the drum on a wet sheet of paper placed on a smooth flat surface. The fork was set in vibration each time by a blow from a mallet, which will explain the rapidly decreasing wave heights. It can be plainly seen from the record how the engine speed varied, the relative position of the wave crests shifting progressively.

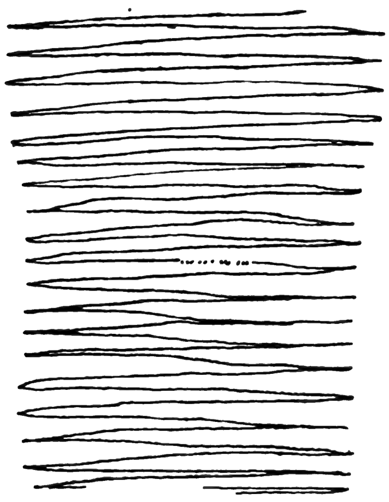


FIG. 3.—VALVE CARD.

A means of getting a continuous-speed record is to place on the engine fly wheel or hub, a raised contact which will touch a stationary brush once every revolution. In the circuit thus completed is placed a battery and a Morse recorder through which the tape is drawn at a constant known speed by passing through a pair of wooden pulling rolls driven from a source like either of those described for the break wheel in the second method mentioned above. Knowing the speed of the tape, a distance equal to the feet per minute traversed by it can be marked off at any part and the number of contacts in that space will give the revolutions made during that minute. Any variation in speed will also be shown by unequal spacing of the dots.

Very pretty tests can be made on those engines having shaft governors, in two simple ways. All governors of this type vary the throw of the eccentric to change the point of cut-off by shifting it across the shaft in a line that may be either straight or curved to a greater or less extent. This being the case, a given point on the eccentric will vary its distance from the shaft center with different governor positions and will hence describe circles about this center of varying diameter. With a steady load, therefore, if we secure a pencil point to the point selected and hold against it a board covered with paper, a circle of a certain diameter will be traced; when the load decreases, however, the governor will shift the eccentric so as to give a larger throw, and the circle will be increased in size. It evident that the number of turns made by the spiral traced intermediate between and connecting the two in the course of passing from one to the other will be the number of revolutions that it has taken the governor to readjust itself, and that any hunting or sticking will be shown by an irregular rate of increase in the spiral's pitch.

The other plan is to fasten the pencil to a point on the valve rod and to move downward at right angles to the direction of the rod's motion, a strip of paper wider than the greatest valve travel, on which would be drawn in passing between the pencil and a backing-strip, a zigzag line. The lengths of each portion of this line are proportionate to the valve travel and show in the same way the number of strokes made between the time the cut-off was made under the first conditions and under the new ones. The rate of increase in length of the strokes also shows whether the rate of change was constant or not.

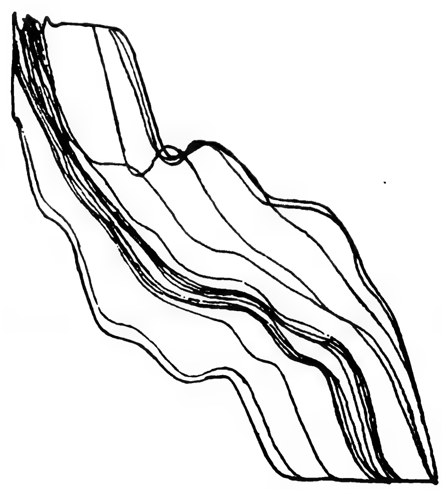


FIG. 4.—INDICATOR CARD.

A common steam indicator will also show the number of strokes that are made before the governor settles down to a new position.

Examples of cards taken simultaneously with these last three methods are given herewith, from which it will be seen how clear the records obtained are. The valve-rod diagram only shows a portion of the period during which the indicator and eccentric cards were taken as the device employed allowed of only a small card travel, the small extra decrease in throw occurring later, as seen from eccentric record.

It may be remarked as regards the indicator diagram, whose outline may appear rather unusual to most, that the indicator was a special one in which the indicator barrel took steam both above and below the piston, the two ends being constantly open to the steam in the two engine cylinder ends, thus giving at once the combination card.

WATER RHEOSTATS.

PRACTICAL USE OF WATER RHEOSTATS

BY EDWARD J. WILLIS.

Any one can make a water rheostat, and any one can run one, but the first time one tries the job, there is some uncertainty as just how to begin, and just what it will do after you have got it running. This article is not to help those who know all about water rheostats, but to give a few pointers to those who may have to take up the job for the first time, and also to offer a few suggestions to those who have already had such experience.

As in most other things, it depends upon the purpose for which the resistance is needed, just how it had best be made. The usual water resistance is not a steady resistance. By this I do not mean that it is a fluctuating resistance (i. e. jumping up and down), but it will not stay at any one thing for a long time under a heavy current. It is, if properly made, most readily adjustable, and with at all careful handling, entirely satisfactory results may be obtained; but he who thinks he can leave a water resistance at a certain number of amperes and go uptown and come back and find the ammeter where he left it, would probably be surprised to find his amperes twice what he wanted. This action of decreasing its resistance is particularly noticeable if the plates are new. Use readily changes the surface character. It is also caused by electrolytic action increasing the amount of salt held in solution by the water. The result of this action is that the plates must be lifted out of the water from time to time to counteract the increasing conductivity. It is sometimes surprising to find how rapidly such an increase of resistance takes place, especially if too much salt is added to the water when starting.

A good many tables of conductivity per cubic feet of water at such and such percentage of salt, etc., and also much data as to current density per square foot submerged, are available. It is not, however, the opinion of the writer that the tables of either water resistance or current densities are of much service in the operation of the water rheostat. There are two factors so readily and so widely variable that it is very much easier to start with a resistance considerably higher than needed and cut down to what is wanted, than it is to go to much figuring in the matter. The two factors referred to are the percentage of salt in the water, and the extent of immersion of the plates. As one can start with plates out and no salt, it can be easily seen, that with a little practice the current can be adjusted up to the capacity of the rheostat.

A water rheostat, as usually constructed, consists of two plates partly immersed in water, one being connected with the positive lead and the other with the negative, and either or both plates adjustable, so as to vary the extent of immersion. The method of lifting the plates, of course, depends upon conditions, size of plates, etc. As a rule, a block and fall is very convenient and cheap, as the ropes themselves form good insulators.

It is well to screw the plates to a good-sized timber, such as a sawed tie, and attach the falls by screw eyes to the timber. Flexible cables form the best method of connecting the plates. The character, thickness, etc., of the plates is not important. It is usually best to purchase old-iron boiler or tank plates. Rust makes no difference, but it is best to remove paint. The thickness of the plates is not important, so long as they are thick enough to prevent their striking against each other when handled, and thus forming short circuits. The distance apart of the plates is also unimportant, as the resistance is not affected by this.

It is best to place the plates 5 or 6 ins. apart, so as to prevent any possible chance of their touching each other. The tank may be either of iron or wood. Wood is the best, as it is less likely to short-circuit the plates, and is easier and safer to handle. The wood tank is also much better suited to railway circuits, as the iron tank is quite likely to make a ground.

The first question which naturally arises when one starts to make a water rheostat, is, How big must the tank be, and how large the plates? As stated before, this depends upon the purpose for which you want the resistance. It is safe to say that they are generally made too large, and that the usual water resistance is considerably under-estimated in capacity. It is best to look upon a water rheostat as a method of dissipating heat. Electricity practically takes the form of heat as soon as it reaches the rheostat. One of the best ways of absorbing heat is to transform it to a latent heat. As soon as the water in the rheostat starts boiling this process has commenced, the steam produced taking up the heat.

The rheostat should be placed outside of the building, or so located, that its vapor or steam will not injure the machinery or electrical apparatus. When so located the rheostat can be permitted to boil away. The capacity of the rheostat is therefore like that of a kettle, dependent upon how soon it will boil over. By putting in water in place of that boiled away, a constant level may be maintained. Should it be desired to force the rheostat, a current of running water can be introduced, and by providing suitable overflow arrangements, the capacity of the rheostat can thus be greatly increased. The easiest way of introducing water into the rheostat, is by the means of a hose let down to the bottom of the tank. It might be well to suggest that a wire-wrapped hose is a dangerous article, especially if railway circuits are under test.

Use an old piece of hose, as the boiling water will probably ruin a good hose. By regulating the water flowing in with the cock or valve to which it is attached, excellent results can be obtained. One is inclined to use more water than necessary. Often the tank boils away steadily and quietly, and it is only necessary to replace the water as evaporated. Sometimes if the resistance is decreasing, owing to the electrolytic action on the plates, by turning on more water, the old salt water is flowed off, and the resistance of the rheostat can be kept steady by regulating the water. If the current of water run into the rheostat is very large, one might think that the large current of fresh water would weaken the salt solution and increase the resistance too much. This increase of resistance may take place under very heavy work, but the writer has not found this to have been the case in any of his work.

The following test, made by the Baltimore & Suburban Railroad, gives an idea as to how large currents may be carried by comparatively small plates: This road not very long since tested a 100-KW booster and an 800-KW generator, by lowering, with block and fall, iron plates into the dock alongside the power house. The data on the booster test are, plates 1 ft. × 5 ft. × ¼ in.; maximum depth of immersion, 2 ft; maximum voltage, 625; maximum current, 800 amperes; maximum immersed surface, 2 sq. ft.; maximum current density per square foot immersed, 400 amperes. On the generator test the same plates were used, the maximum depth of immersion being 2 ft.; maximum voltage, 550; maximum amperage, 1450; maximum immersed surface, 4½ sq. ft.; maximum density per square foot of immersed surface, 322 amperes.

It is not generally the case, however, that the salt water is found convenient to the power house. Wells or ponds can be used by putting salt in them. It is usually the case, however, that it is best to put in some form of tank. The writer recently conducted a test on two 300-KW units, in which a tank 4 ft. × 4 ft. × 5 ft. was used. This tank could easily handle 1000 amperes at 550 volts. Running water from a fire hose was found necessary to keep the tank from too violent ebulition. The maximum depth of immersion of plates was 3 ft.; the maximum area immersed, counting both sides of both plates, was 36 sq. ft.; maximum current den-

sity per square foot, 280 amperes. Much higher current density can be used if the body of water is large, as when the plates are thrown over a dock or submerged in a pond.

For the usual run of work, testing, etc., the writer would suggest the construction shown in Fig. 1. A 55 or 60 gallon barrel is used, and an ordinary sheet of galvanized iron rolled over and riveted to a cylindrical form makes the outside plate. The inside plate, which should be the positive one, is made of the same material about 6 ins. smaller in diameter.

One barrel so equipped will easily handle 50 KW, and on a pinch with plenty of running water, and where steadiness is not essential, 75 to 100 KW may be taken by the barrel. By putting in one of these barrels for every 50 or 75 KW according as to whether steadiness is essential or not, one can obtain very satisfactory results without much cost as to construction. As all the barrels are not likely to boil over at the same time, fairly steady results may be obtained, even when driving these barrels quite hard. Where accurate regulation of current is needed, such as for one or two arc lamps on a 500-volt circuit, or a vitascope, etc., the writer would suggest that the plates be cut away to a spiral form, as shown in Fig. 2. By this method the current starts from practically nothing, going steadily up to a maximum, and the regulation becomes more sensitive as the current diminishes. (The engraver should have made the spiral edges straight in Fig. 2 instead of jagged.)

It would not be out of the way to caution any one using a water rheostat for the first time, as to the small amount of salt needed. The amount of salt depends upon the voltage and the current needed. With the

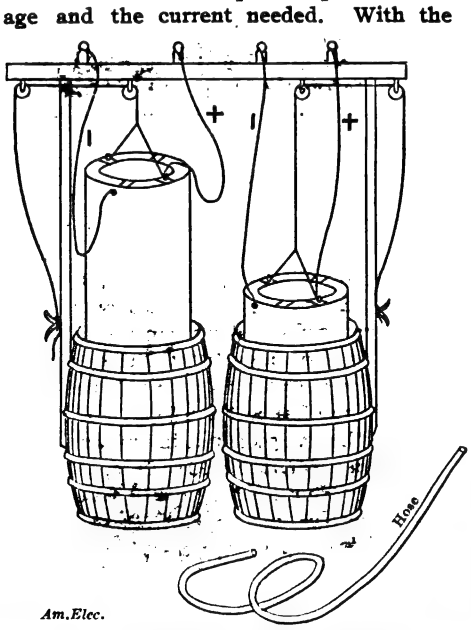


FIG. 1.—BARREL WATER RHEOSTAT.

60-gallon barrel mentioned above, and 550 volts a tablespoonful of salt is an abundance; and if a small current, say under 50 amperes, is needed, it would probably be better to use no salt at all, but simply to start up the rheostat and let it run a while until the electrolytic action has produced sufficient conductivity. If on putting in salt the current does not immediately respond, wait a little while, for it takes some time for the salt to diffuse, even with stirring. One should not keep on putting in salt if the rheostat does not start up to the desired current. If too much salt is put in at first, the conductivity will increase too rapidly, and the test will probably end with the plates only just a little bit in the water. This is bad, as it not only reduces the ease of adjustment, but also concentrates the heat at the surface of the water, and in so doing reduces the capacity of the rheostat.

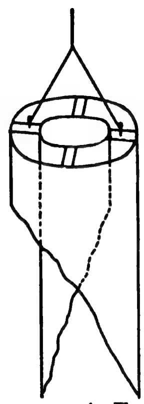


FIG. 2.—RHEOSTAT WITH SPIRALLY CUT PLATES.

Where a perfectly steady resistance is required, an immersed wire rheostat may be employed, which is ordinarily the wire box rheostat dipped in a barrel of running water. Very fine wires may be used if a good supply of running water can be kept going through the barrel. German silver is probably the best wire to use, as it does not easily rust. Iron wire can be employed, but it has to be carefully dried and varnished after being used. If too much varnish be allowed to accumulate on it, it is likely to make it burn out. The capacity of such rheostats is very small, probably not being usually over one-tenth that of a plate rheostat of the same size.

Persons have sometimes curiosity as to the voltage of the water in a water rheostat. The voltage of the water varies with the location. Around and at the negative plate, it is nothing. At the positive plate it is positive. Between the two it falls off gradually. The result is, that the amount of current felt on immersing the hand into a water rheostat depends upon the place where the hand is immersed, and the extent of immersion. If the hand reaches from a negative to a positive locality, a very heavy shock is sustained. A water rheostat with sufficient distance between the plates to enable a man to bathe without danger of touching the plate, would form an almost ideal electric bath in which a current in any desired direction, and of any desired strength, could be obtained by a single movement of the body.

A NOTE ON WATER RHEOSTATS.

BY E. A. MERRILL.

Several years ago I, in conjunction with several other students, made a short series of experiments on the use of water rheostats with small currents. These experiments were for qualitative rather than quantitative results, and therefore only generalizations can be drawn from them; but as such generalizations may have a certain value through indicating the direction in which more accurate results can be obtained, they are here recorded.

A trough of rectangular section, about 6 ins. deep and wide, by 6 or 8 ft. long, was constructed out of planed pine boards. This trough was first filled to within about an inch of its depth with water from a hydrant-water probably of an average purity, it being used for drinking purposes and drawn from reservoirs up among the country hills.

Two triangular electrodes were made from sheet copper and crudely attached to copper leads. The source of current was a storage battery, this serving both to give a constant e. m. f. for any given set of conditions and a convenient method for varying the e. m. f. to suit different sets of conditions. Measurements were made with a Weston ammeter in circuit, with one of the electrodes and a Weston voltmeter across the terminals. By varying the e. m. f. as the resistance in circuit was varied, a wide range of readings was possible without at any time exceeding about 20 amperes.

A very few readings showed that though the water was chemically far from absolute purity, yet it was too pure to give satisfac, tory results as a resistance—its resistance proved to be approximately 100 ohms for a volume 1 ft. in length having a cross section of 1 sq. ft. This extremely, and unexpectedly, high resistance made it necessary to bring the electrodes so close together for large currents and low pressures, say 10 amperes and 10 volts, that fine gradations were impossible, the slightest movement causing wide and erratic fluctuations. It was observed that so long as the current density was sufficiently low not to cause violent ebulition, the resistance was but little affected by changes in the current density or by the length of time it flowed.

It was also observed, both in this and the further experiments, that when the current density was sufficient to cause violent ebulition, the apparent resistance fluctuated constantly and widely, due, doubtless, to the gathering of gas bubbles on the surfaces of the electrodes, thus diminishing their effective area.

The next experiment consisted in taking new series of measurements after diluting the water with various quantities of commercial oil of vitrol or sulphuric acid, the trough having first been cleaned and supplied with fresh water.

The reduction in resistance was even more marked than with a salt solution for equal quantities of acid by weight. The results are tabulated below, and are for a volume of the solution 1 ft. in length and having a cross section of 1 sq. ft.

Per cent. acid.	Resistance in ohms.
.174	4.12
.435	1.75
.724	1.10
.985	.85

Per cent. acid by weight.

The use of acid gave fairly uniform results. For a given degree of dilution the resistance remained nearly constant with varying current densities and over considerable periods; the gases escaped freely from the surfaces of the electrodes and corrosion was slow.

The next experiment consisted in taking

new series of measurements after mixing various quantities of table salt in the water. The change in the resistance of the salt solution was very marked and the results, reduced to the equivalent of a volume of the solution 1 ft. in length and having a cross section of 1 sq. ft., are given in the following table:

Per cent. salt.	Resistance in ohms.
.23	7.84
.46	4.65
.70	3.12
.93	2.38
1.16	1.9
1.39	1.48

Per cent. salt by weight.

The use of salt gives a cheap and convenient method for widely varying the resistance in circuit, but we found it very untrustworthy for accurate work. The chlorine gas set free in the decomposition of the solution is extremely corrosive, eating away the electrodes very rapidly and forming a heavy scum of a comparatively low specific resistance, which gradually accumulating on the surface rapidly diminished the ohmic resistance between the electrodes. The results given above are from readings taken when the surface was clean. Moreover, this scum served to imprison bubbles of hydrogen and when an electrode was withdrawn from the solution they were occasionally ignited, as the current was broken, with a flash often sufficiently intense as to be dangerous if one's hand or face were too close.

FUSES vs. CIRCUIT BREAKERS.

CIRCUIT BREAKERS A STEP BACKWARDS IN ELECTRICAL PROGRESS.

BY HARRY H. CUTLER.

The same old subject is good enough for me, and I have nothing to retract from what I stated in my articles on this subject, which appeared in the August and October numbers of the AMERICAN ELECTRICIAN.

Anyone who has studied the many interesting articles which have been published, beginning with the August issue, on the subject of "Fuses *vs.* Circuit Breakers," will readily agree that the advocates of properly designed fuses are away ahead in the controversy. It is of no use, now, for anyone to talk about the unreliability, variable melting points, destructive arcing and general cussedness of fuses. Such remarks apply only to plain wire, open fuses which, as I stated in my first article, are a disgrace to the electrical profession.

Reliable, accurate, and non-arcing fuses are on the market, and they are here to stay. They will be welcomed with open arms by the Fire Underwriters and progressive electrical engineers, and the magnetic circuit breaker has got to take a "back seat." I have already placed myself on record as believing that the enclosed cartridge fuse is preferable, both electrically and mechanically, to any magnetic circuit breaker ever yet placed upon the market. I will concede one, and only one, possible advantage possessed by the magnetic circuit breaker, namely: The low cost of closing the circuit after it has been opened.

Various articles in this discussion have demonstrated that the properly designed fuse will open the circuit as quickly on heavy overloads as a circuit breaker; that they are accurate enough for all practical purposes; that by using magazine holders the circuit can be quickly closed; that the fuse has the desirable feature of having a time limit, and that the fuse depends for its operation on the same heating effect of the electric current against which it is intended to protect the apparatus; that "up-to-date" fuses make no flaming arc, and are the acme of perfection, as regards fire risk. They are simplicity itself, low in cost and impossible to get out of order. The magnetic circuit breaker is a back number in the light of the recent developments of the fuse. The subject of my several articles implies this, and yet it appeared so bold that even the editor of this paper felt obliged, in an editorial, to state that he could not agree with me. But I am right, and firmly believe that magnetic circuit breakers are a step backwards in electrical progress, and are fast becoming an unmitigated nuisance.

They have flourished, as Mr. Joseph Sachs says, in his most excellent article, in the November issue, on account of the many shortcomings of the common type of fusible cut-outs. I want to say right here, that this article of Mr. Sachs is sound engineering, from the beginning to the end; that I agree with every word of it, and would not ask for a better support in the position which I have taken.

Referring to Mr. Harrington's article, he is, of course, correct in his statement that the "arcing, following the initial opening of the circuit breaker provides the wherewithal, and saving factor of the device;" that is to say, it introduces resistances before the current actually ceases, and thus lessens the shock, both electrical and mechanical, upon the system. This protection, however, does not go nearly so far as a rheostat, and the idea of holding up a long flaming arc as preferable to a sparkless, harmless rheostat, after all that has been said about supplying apparatus which possesses a minimum fire risk, is simply preposterous.

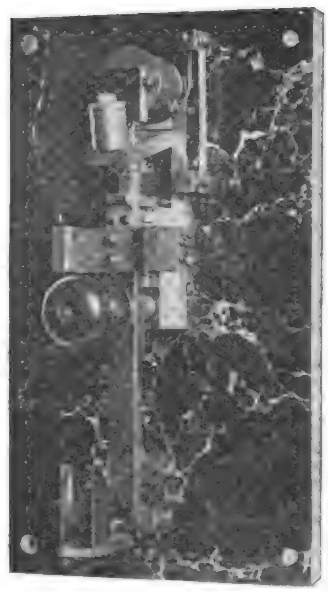
Mr. Harrington further states that "The reason circuit breakers are preferable to fuses, even in the extreme case of elevator motor protection, is due to the uncertainty and unreliability of fuses in connection with their notoriously bad quality of permitting such enormous currents to flow in event of a short circuit." Such a statement as this is utterly and absolutely untenable, when applied to the enclosed cartridge type of fuse, which all the advocates of the fuse have been talking about, and shows either that Mr. Harrington has not informed himself about "up-to-date" fuses, or else purposly ignores their advantages. As for using an open copper wire for a fuse, I certainly agree with him that a circuit breaker would be much better than such a foolish makeshift of a cut-out as an open copper wire.

The best use for circuit breakers seems to have narrowed down to where the load is extremely variable and excessively abnormal currents are of very freqent occurrence. But even in these cases, the ordinary magnetic circuit breaker is continually operating at every little abnormal, temporary fluctuation of current, when there is no necessity for operation, thus constituting a nuisance.

What then, is the proper protection to use in such cases? I answer this question by describing a "heat controlled circuit breaker," which I have recently designed. The accompanying cut shows a 75-ampere, 500-volt single pole circuit breaker of this type.

Its operation depends upon the combined magnetic and heating effect of the current. Every electrical connection and every part is plainly shown in this cut, and there is nothing concealed except its principle. The mechanism and the principle of operation, however, are both exceedingly simple and easy to understand.

The small magnet at the top attracts the armature before the circuit breaker opens, and strikes a sharp blow upon the catch, which holds the switch closed in the ordinary manner. A strong spiral compression spring throws the switch open when the catch is released. The only material difference between this breaker and the ordinary magnetic circuit breaker lies in the connections. The small magnet is wound with



TIME LIMIT CIRCUIT BREAKER.

copper wire of sufficient cross-section to carry the current without heating, and it is used as a mechanical means for releasing the catch.

The operation of this magnet is controlled by the heating effect of the current. An overload of 50 per cent. or more in excess of the amount at which the circuit breaker is set to open, will cause the circuit breaker to open instantly, by the magnetic effect of the current alone, and it is only in cases where

the overload does not exceed 50 per cent. that the time-lag waits for the heating effect of the current before the magnet operates. By using this combination of the effects of the current, it will be seen that a more precise and definite action can be obtained than even with the most improved enclosed fuse.

For example: Take a 100 ampere improved fuse, and my time limit circuit breaker, set at 100 amperes. Connect them in series, and send 150 amperes through them. The circuit breaker will open instantly, and the fuse will not blow. Again, suppose that 90 amperes has been flowing for several minutes through these two devices, connected in series. Neither will operate. Now increase the current to 100 amperes. The circuit breaker will then open instantly, and the fuse will not blow.

Greater precision, therefore, can be obtained by the use of a circuit breaker which is influenced by both the magnetic and the heating effect of the current, than can be obtained by the best designed fuse. Understand, however, that under no condition do I recommend the use of even my own time limit circuit breaker, except where the circuit is continually being overloaded, and the cost of renewing the circuit with improved fuses would make it cheaper to use a circuit breaker.

It should also be noted that my time limit circuit breaker does not hesitate in opening, except when either a small, or no current at all, has been flowing before the amount reaches, or exceeds the normal to which the breaker is set.

For example, on the first closing of the circuit, 150 amperes will flow for nearly a second, through a circuit breaker set at 100 amperes. 140 amperes will flow for about two seconds. 130 amperes, much longer, and so on.

This principle would enable the time limit circuit breaker to have its greatest use on motor circuits and railway feeder lines, where the load is greatly fluctuating, and time is given between the minimum and maximum flow of current for the heat regulating part of the circuit breaker to cool off, and thereby allow a temporary abnormal flow of current to pass for a few seconds without opening. I submit this principle to the careful consideration of electrical engineers and will endeavor to describe more fully the operation, and principle of this device, in another article.

FUSES AND CIRCUIT BREAKERS.

BY JOSEPH SACHS.

In a recent article the writer endeavored to show the superiority of fuse protection, but coincident with its publication appeared a defense of the circuit breaker, which has suggested the following remarks. As a refutation of the points advanced in the previous articles to which it refers, this defensive argument appears to the writer rather weak.

The writer refers to the injurious inductive effect resulting from the rapid opening of an electric circuit. The excellence of the example quoted need not be considered here. Let us assume that such a condition may exist. Several circuits supplying inductive loads may be equipped with circuit breakers in one case, fuses in another. Quoting, we are told that "The induced electromotive forces established in the circuit owing to the quick opening are amply taken care of in the flashing or arcing provided for at the jaws or main break of the circuit breaker." * * * "Every provision is made to do this duty by providing carbon points for the final opening." * * * "The carbon break with its arc has the advantage, both electrically and commercially, of inserting resistance in circuit."

No one will deny that the ideal method would be to gradually, instead of instantaneously, shut off the circuit supply when necessary. The electric arc furnishes such a graded shut off, but if we provide every possible means to instantaneously break this arc, as is essentially provided for in all circuit breakers, only a small part of the possible attainment of the desired comparatively slow and gradual shut off is obtained. It seems, therefore, that in this class of apparatus we are really between the deep blue sea and another individual. If we open too quickly—injurious inductive effects; and if we go to the other side—injurious flashing and arcing results. A series of graded resistance breaks is possible and has been embodied in such devices, but as long as the opening time interval is almost instantaneous, satisfactory results can only partially be attained.

Why, however, credit to the circuit-breaker these peculiar advantages, due to an effect which it has been desired to annihilate as much as possible by instantaneous spring-opening mechanism? It is well to know that even this cloud has a silver lining, but this same cloud has darkened the life of fuse cut-outs and the silver lining has never been thought of. If this arcing effect is so excellent a characteristic in any cut-off protective device, it is certainly entirely too prominent in the fusible cut-out of the present type for its welfare.

The arcing on present fusible cut-outs, particularly those of short length used on high potentials and large currents, has always been considered one of the most prominent of its many defects. With heavy loads, even with the best construction, it means nothing short of destruction, complete or partial.

To quote again, "more troubles have been experienced by engineers due to fuses designed to prevent arcing." Presumably the type of fuse referred to in previous articles is to be placed in this category. The prevention of serious effects due to arcing, and its elimination are two separate and distinct considerations. It would be almost impossible to devise a commercial fusible cut-out which would eliminate the gradual rupture of the circuit through an arc or a similar effect. In the improved fuses mentioned in the writer's previous article this effect, although not apparent on the surface, is really aggravated in the interior. There is the same difference between the open air and the enclosed fuse as between the open air and enclosed arc, as utilized in the well known arc lamps. It may be interesting to those who assail the capabilities of fuse devices to know that fusible cut-outs can be built which not only fulfil all the conditions of gradual shut-off equally as well as any circuit breaker—which, in fact, any open air fuse would do—but accomplish this result without any exterior arcing manifestation, and with a gradually increasing resistance attaining the infinite in a very appreciable time interval.

All who are thoroughly acquainted with the workings of heavy short-circuit current are thoroughly "acquainted with the advantages provided in a device that will in its initial operation open the circuit more and more quickly as the current causing such opening increases." It is for this very reason that one cannot fail to see the peculiar advantage of a device whose rate of operating ability increases as the square of the current.

Certainly, if we rate fuses at 50 per cent. below their maximum continuous running carrying capacity (at perhaps 20-25 per cent. above which they blow), we can scarcely expect the same results as in a circuit breaker, which is run at a much closer margin. Take, however, a circuit-breaker set to open, say, at 5 per cent. above its maximum continuous running point, and compare it with a fuse which will run continuously at the same maximum running point and blow in, say, two minutes at 10 per cent. overload, and probably the investigator will find the final maximum current value in the case of the fuse to be, if anything, less than in the case of the circuit breaker.

The law, or rather well known formula, mentioned shows the necessity of a protective device which will operate in a minimum time interval so as to correspondingly minimize the final maximum current. A protective apparatus may follow out to the fullest this principle and yet cause injurious inductive effects if it opens too quickly after having attained the final operating point, even though there be a decrease of the current before actual rupture. Of far more importance, however, is the necessity of a gradual cutting down of the current in the case of dynamo protection. Flywheel accidents are in most instances due to no other cause than the almost instantaneous removal of the entire load from the generator before the engine governor has been able to take care of the increased resulting speed. What engineer would operate the main quick-acting switch connecting, say, even a 200-KW generator to the bus bars and expect good results? Yet this is exactly what happens when the circuit-breaker works.

What is the dividing line when the use of one or the other of these protecting devices becomes imperative? Is there a current strength at which it is essential that fuses be displaced by circuit-breakers, or vice versa. The defender of circuit-breakers tells us that, "fuses above 10 amperes are not objectionable, but as the current increases, the importance of using magnetic circuit breakers increases." To substantiate this conclusion a formula is given showing that wires used as fuses will allow an abnormal flow of current before blowing on short-circuit, although they will go at less than one-tenth of this maximum in a short time interval. We are not told what the maximum continuous rating of the wire is, however. What

would a circuit-breaker do set at the same continuous running point?

For the protection of 500 to 1000 HP units, no one advises the use of open air fuses, even if only the flashing and arcing of such devices is considered. Given, however, a fuse which does not possess this evil, and is worked at a maximum running point which comes close to the blowing point, and has in addition the property of involving time and a gradual breaking off of the current, does it not seem that instantaneous circuit-breakers are inferior?

It may be replied that such single fuses are a difficult attainment. Perhaps they are, but is it absolutely essential that one single fuse wire should protect 1000 HP of current? Those who are unbiased on the circuit-breaker side will certainly acknowledge that the circuit-breaker attained its prominence, not because it affords the best electrical protection, but for other reasons. There are fuses available to-day which are not beset with the failings of their ancestors. These fuses can be utilized and renewed with almost the same facility as any circuit breaker of the same capacity. Why, then, make comparisons between one device of the past and another of the present?

Let us go to the other extreme. Who would use circuit-breakers for the protection of, say, 100 ampere loads if a fuse such as described were available? Who would put circuit breakers in place of fuses at each panel board or other cut-out serving an ordinary interior lighting circuit? Are there not many instances where, aside from all other considerations, the circuit-breaker would be unavailable, if for nothing else than commercial reasons. Even with no other rival than the open air fuse it is safe to say that the circuit-breaker would never reach this field. Why should it be considered in any way superior or even equal to a fusible cut-out with features as have been indicated, except when the renewal of the circuit becomes of the utmost importance, and when the operation of the protective device would be so frequent as to prohibit, for commercial reasons, the use of a destructible cut-off? Even these features may be embodied in the fuse cut-outs.

COMPOUND DYNAMOS AND THEIR ACTION.

BY JAMES T. JENNINGS.

It is the general practice of to-day in all power stations supplying current for railway-motor work to run compound-wound generators in multiple. The action of such generators is very often misunderstood by the average power-house engineer, and I regret to say that the statements coming from intelligent electricians are very often misleading, owing to the fact that insufficient study is given to this important subject. There are several conditions under which compound dynamos can be run in multiple.

The universal method in use to-day, owing to its simplicity, and one which has proven to be most practical, is the employment of an equalizer.

This equalizer is sometimes placed on the switch-board and sometimes at the dynamo terminals.

The advantages gained by equalizing at the dynamos are less copper, while the generators are rendered more sensitive to changes in the load and act more in unison with varying loads; but apart from this the equalizing connection is erroneously credited with a remarkable power of control over the output of dynamos which it does not, and cannot, have, as we can readily see by watching the instruments in almost any station, as well as by an examination of the characteristic from the testing sheet.

The common idea is that the equalizer has the property of compelling a lagging machine to take its share of the load, and we very often hear of the wonderful power of control it has over dynamos of different types and sizes, even when working under different conditions. The office of the equalizer is to put the series coils in multiple with each other, so that the flow of current from the station will divide between the dynamos inversely as their resistance, regardless if the current comes from one, or is divided among many. Hence, it is very clear that it cannot in any way exercise even the slightest regulating effect on any one dynamo that it does not have over all. The armatures are running in parallel under exactly the

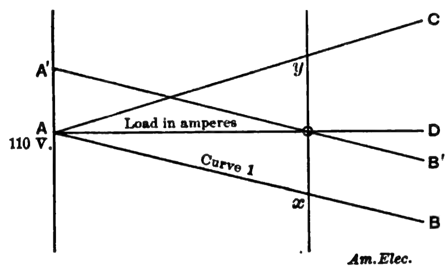


FIG. 1.—DYNAMO CHARACTERISTICS.

same conditions as though there were no series coils at all.

Hence, we see that the characteristic of the plant is a falling one as far as the armatures are concerned to which we have given the automatic regulation of the multiple-series coil; these act in unison in proportion to the total flow of current from the plant, and providing these series coils are alike, each generator will alter its voltage in proportion to the output of the plant, but each armature will not take its share of the load unless the characteristics of each machine are precisely the same.

A simple shunt machine has a drooping characteristic, as shown in the curve of Fig. 1. This is due to several causes. As the load increases the usual fall of speed occurs at the engine, due simply to the action of the governor; the dynamo pulley also lags on account of the increased slip of the belt as the load becomes greater; there is also the demagnetizing effect of the armature, which reduces the voltage, and the fall of potential in the armature wire, leads, fuses, connections, etc., up to the point of distribution. The sum of these separate losses is shown in Fig. 1, curve 1, $A B$.

The voltage is proportional to the speed, to the number of conductors on the armature and to the magnetic flux. The number of conductors is evidently not changeable, but by increasing the speed or the flux, we can increase the E. M. F., and by varying them by the right amount we are able to overcome the effect of the above reactions. We could obviate the difficulty by increasing the speed, but this is not in general practical, and the flux is the factor which is commonly changed.

The method used to change the flux in the simple shunt machine is to have a rheostat in the field circuit, and by moving the position of the rheostat arm, the dynamo can be made to give the proper voltage at any desired load, since the position varies the resistance, hence the current through the field, thus changing the flux. The effect of this regulation can be considered to be a raising or lowering of the net characteristic bodily, without any material change in the inclination. Suppose $A B$ (Fig. 1) is the characteristic of the machine and the load is $A O$; we see that there will be a drop, $O x$, in voltage from the normal voltage, supposed to be 110.

Now if we vary the field rheostat until we get 110 volts at this load, the effect is to raise the whole curve to $A' B'$ and evidently the rheostat must be in a different position to give 110 volts at any other load. This method with a varying load would require some one at the rheostat all the time.

If we wind a number of series turns on the field, their effect in magnetizing the fields will increase with the current, and hence the flux will be increased; that is, the flux will increase with the current, but not proportionally, as the permeability is not constant. By adjusting the number of turns by trial, we can so arrange it that the rise in voltage due to the series winding balances the effect of the reactions which tend to lower the voltage.

This is represented in Fig. 1. Here $A C$ represents the volts rise which the series windings would give, and $A B$ the characteristic of the machine; the resultant curve will be $A D$, and hence the voltage will be constant.

Simple shunt machines may be run in parallel without difficulty if the units have similar characteristics, but if not, we will have considerable trouble, as the machine with the steepest characteristic will not take its share of the load when it increases, and will take more than its share with a decrease of load.

Let the lines, $F G$, in Fig. 2 represent the characteristic of two machines. When the armatures are in parallel and giving no current, let the voltage be brought to 220 volts, when the two lines will intersect at x.

Now, if we put a load of 74 amperes on the dynamo it will cause the voltage to drop to 205 and G will deliver 45 and F 29 amperes.

Suppose we equalize the load with 37 amperes in each armature and bring the voltage up to 220 by means of the rheostat; we thus raise the lines $F G$ to $F' G'$, intersecting at b. Now, if the load be diminished from 74 amperes to 16.5, we see that the voltage will rise to 231.6 volts and F will deliver 14.5 amperes and G 2 amperes.

Thus we see when two dynamos with characteristics like these are subject to a rapidly changing load, it is impossible to evenly divide the current, and the result is F will drive G as a motor and the fuses will undoubtedly blow.

When the machines with series windings, or compound machines, are run in parallel,

one machine will almost invariably overcome the other and run it as a motor.

Fig. 3 represents the two machines with the series and shunt fields. If the machines were at the same voltage when connected together, no current would pass from one to the other, but if the load and, consequently, voltage varies ever so little, current will pass from the one of higher voltage, say, No. 1, to the one of lower voltage, say, No. 2, as represented by the arrows. The effect of this reverse current in the series

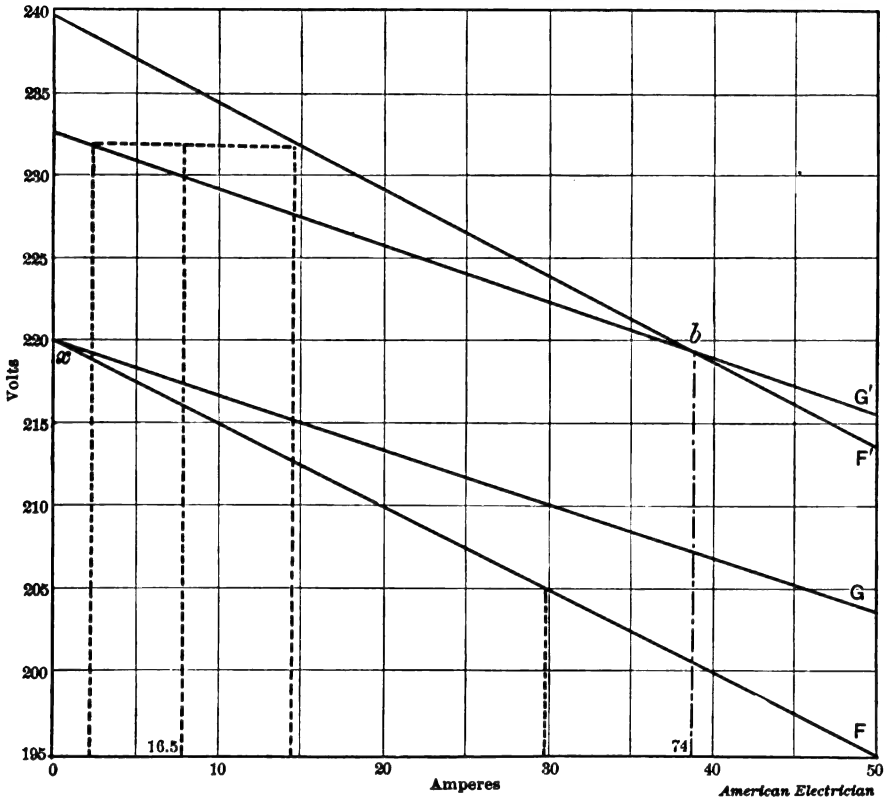
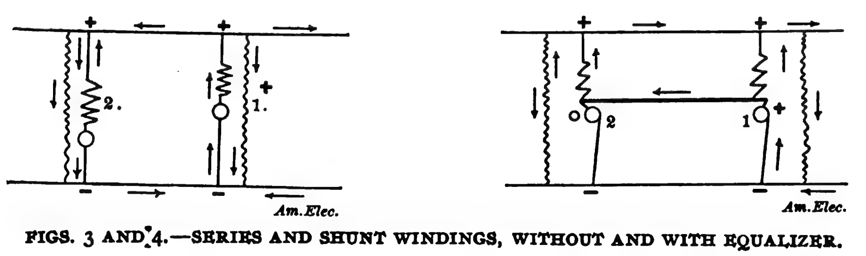


FIG. 2.—DYNAMO CHARACTERISTICS.

field is to reduce the magnetization and thus further reduce the voltage; this keeps on until machine No. 2 having its fields so reduced, is far below No. 1, and the result is the fuse in the armature circuit of No. 1 will be blown. This is caused by the machines not giving the same voltage, and in view of this fact the current will flow from the machine of higher voltage to the one of lower voltage, passing through the series field in opposition to that of the shunt windings, thus demagnetizing the fields.

If the current could be made to go through



FIGS. 3 AND 4.—SERIES AND SHUNT WINDINGS, WITHOUT AND WITH EQUALIZER.

the series coils in a direction to magnetise the field, it would raise the voltage of the machine and keep them all right.

This is accomplished by running a wire from the + brush of one to the + brush of the other which is at the same voltage. This is shown in Fig. 4 (ox), and is called the equalizer. If one machine, as No. 1, is a little above No. 2 in voltage, the connection x will be above o in voltage, and a current will flow from x to o as shown by arrows, around the series field of No. 2 in the right direction to magnetize the fields and increase the voltage, thus bringing the voltage of machine No. 2 up to that of No. 1.

More than one machine thus connected will work well under all loads, and compound machines of different size and current capacity may be connected as above without serious trouble, provided the resistances of the series field coils are inversely proportional to the current capacities of the several machines; that is to say, if a dynamo is to give twice as much current; its series coil must have half the resistance. To adjust the effect of series coils in compound dynamos, a shunt of German silver is put across the series coils until the desired potential is secured.

This shunting method operates properly in the case of machines working singly, but when such machines are put in multiple it is worthless, and has no effect on the relative actions of the series coils of the dynamos, because then all coils and all shunts become parallel conductors, and are traversed by currents inversely proportional to their resistances.

The shunts merely diminish the total flow of current through the series coils, but in no way do they serve to adjust the effect of the series coils relatively to each other.

Suppose one dynamo is very much overcompounded and we shunt it for the desired percentage rise, and another one only slightly overcompounded which will be only slightly shunted; we can plainly see that when the shunted series coils are in parallel, the shunts will only have the effect of affording a path for a part of the total flow of current, and consequently could be wired in any convenient place. We would then have two dissimilar overcompounded machines working in parallel, and in all probability an increased load would be largely carried by the machine having the greatest number of series turns, because an increase in the total current flowing would raise the voltage of this dynamo faster than that of the other.

MATHEMATICS FOR ENGINEERS, ELECTRICAL AND NON-ELECTRICAL.

BY TOWNSEND WOLCOTT.

The question often arises, how much mathematics is useful to the engineer? If I were required to answer this question in a half-dozen or less words, I would say, so much as he understands. Not that this is absolutely true, but because it is better than any other equally short answer I can think of. This answer might provoke another question, How much mathematics *must* an engineer know? The answer to this is, Very little beyond arithmetic. It is perhaps not so true that all the higher mathematics an engineer can thoroughly master will be of use to him in his professional work, as is the converse proposition that it is only that part which is thoroughly learned and digested that is of any use. It is pretty safe to assume that in the majority of cases where an engineer does not find an application for all the mathematics he has studied, that it is because he does not know them sufficiently well to use them with facility.

Anyone who is well posted in all sorts of unusual arithmetical operations, will find frequent use for them, although most persons would consider them only arithmetical curiosities. For example, suppose a machinist were to receive an order for an accurate screw with millimeter or other metrical threads. Suppose, further, that he had good screw-cutting lathes, but that their lead screws were all cut to pitches in aliquot parts of an inch. How will he cut the thread? He must solve a problem in continued fractions, in addition to the ordinary process of calculating the gears for screw-cutting. That is only arithmetic, not even algebra, yet comparatively few engineers understand continued fractions. The problem may be solved otherwise, but continued fractions give at once a series of approximations, each the closest possible with numbers of the same magnitude. Consequently, one knows at once the smallest number of gear teeth that will cut the required pitch with any given degree of accuracy.

This is one instance where continued fractions are useful, and there are lots of others, to say nothing of cases where other unusual arithmetical operations are handy. But to the question whether it pays an engineer to learn all sorts of unusual arithmetical operations, I would say, that depends on the

man. Some persons take kindly to mathematics by nature, and others have a natural antipathy to them. One who finds it an onerous task to learn a method like continued fractions, would probably find it did not pay; that is, from a purely commercial point of view. If his practice involved the solution of such problems, he could pay someone else to solve them. But from a more professional point of view, it would still pay him to "waste" a little time on studying that sort of thing.

The use of logarithms, as distinguished from their theory, is a branch of arithmetic, and every engineer ought, of course, to be able to perform multiplication, division, involution and evolution by means of logarithms. The same may be said of the use of tables of circular functions as regards their more common uses. Algebra to equations of the second degree is exceedingly useful, though a great many engineers get along without it, or at all events, without really understanding it.

It is not merely the ability to calculate, however, that constitutes the utility of mathematical knowledge to the engineer; it is also the increased capacity for understanding the natural phenomena on which the engineering practice is based. It is not too much to say that no one can thoroughly understand alternating-current phenomena without a working knowledge of elementary calculus. It is not necessary that one should be able to actually perform the operations—for example, integration—except in very simple cases, but it is absolutely essential that he should truly understand the principles of differential coefficients of different orders, maxima and minima of functions of a single independent variable, quadrature of surfaces and other fundamental rules.

Any one who can read Maxwell's treatise understandingly, or who, not understanding all of it, can understand the more essential parts of it, will find that there is an immense amount of later literature that is only necessary because the great majority of those who study electricity can not read Maxwell. Thus is the advantage of a mathematical method of treatment of physical science exemplified. After a quarter of a century of progress in that particular branch of science, which is phenomenal in its magnitude, we can go back to the beginning of that period and find much of what is commonly called new discovery, in the original edition of a treatise on that science.

It is evident that the advantage to an engineer of understanding a work like Maxwell's is not lost, even if he never uses any of the mathematics for the purpose of numerical calculations. As long ago as the days of ancient Greece, Aristotle said, "I find the young men who study mathematics quick and intelligent at other studies." The mathematics of the times were chiefly geometry of the Euclidian type, and the method of demonstration was the best training in logic that the times afforded. Indeed, Euclid is a very good book to study now, although some moderns think the fact that it is 2000 years old sufficient to condemn it.

If a proposition in Euclid be presented to a person entirely unacquainted with the Euclidian method (even though educated in other matters), he is not at all apt to say that he does not understand the demonstration, but is much more likely to say one of two other things. If the result looks strange and unreasonable to him, he will say without qualification that it is not so, and if it looks reasonable he will say, any one can see that it is so, and that the demonstration is nonsense. If such a person conscientiously studies the Euclidian method, he will after a while discover that there is something in it; after a longer time he will begin to think naturally in the method; and finally he will look back at his original mental state and wonder how he could ever have been so stupid.

Several times when asked to recommend an elementary algebra to a person who intended to study by himself, I have recommended Day's. This was written by Dr. Jeremiah Day, one of Yale's former presidents. The edition usually found (it can only be picked up in second hand book stores) was published some sixty odd years ago. Of course, it is behind the times, but, oh, ye students of mathematics, know ye that there are worse things even in these days of break-neck progress, than being behind the times. To paraphrase an ancient proverb, it is better to be right than to be up to date.

Day's algebra is didactic and scientific; it is all solid sober reason without fads or frills, and anyone who learns it will have nothing to unlearn, but can bring himself up to date by simply adding later discoveries to what he already knows. I have never seen a modern algebra of elementary grade that was the equal of Day's in method, whatever other excellencies it might possess.

Another algebra of a couple of generations ago, was Peacock's. This was an English work, and not so well known in this country as Day's, but of a somewhat more extensive scope. I mention it here as another excellent treatise, and as a protest against the idea which seems to have gained some currency, that mathematics must be intensely modern in order to be good for anything. I am convinced that if some modern writers on quaternions had read and thoroughly assimilated Peacock's theory of the roots of a quadratic equation, they would have left unsaid some things that they have said with emphasis. The modern advanced treatises on algebra by great mathematicians, are, of course, superior to the older ones, and the foregoing remarks are not intended to apply to them, but to the ordinary text-books, which are read by hundreds for every one who reads an advanced treatise.

Another old book that is of very superior quality, is the calculus in "Robinson's Mathematical Series," by Dr. I. F. Quinby. It is about thirty years old, yet there are very few text-books on calculus, of a late date, that are as good. It has not a word to say about hyperbolic functions, but if one tries to integrate a given expression according to the instructions there given, and also according to the instructions in some modern works, he will be convinced that everything worth knowing about calculus has not been discovered in the last year or two. There are good modern works on the calculus, but it is not proper in an article of this kind to specify the ones that are satisfactory, or otherwise.

The object of mentioning these old books, is to show that it is more important to have a good book on mathematics than a modern one, and several modern books run to fads rather than to sober science.

One of the subjects that has been in some cases carried to the point of being a fad, is hyperbolic functions. There is a certain analogy between the circle and the equilateral hyperbola, and on this is built the the theory of hyperbolic functions. This theory is legitimate, and useful to a certain extent, but not to the extent to which it is sometimes carried. The impression conveyed by a cursory examination of some modern works on calculus, is that both the theory and the labor of performing the operations of integration, of irrational functions are simplified (if indeed one does not also get the impression that more forms may be integrated) by the use of hyperbolic functions. The fact is, however, that any expression that is integrable in terms of the hyperbolic functions is also integrable in terms of the exponential function e to the x power, and sometimes much more simply, as may be found by trial. Hyperbolic functions have apparently attained prominence owing to the fact that they are susceptible of graphic illustration, and as such are an example of a very wide-spread tendency to exalt the utility of graphic methods beyond all reason.

There are cases where the graphic method is all its name implies, where a single look at a curve or other figure will convey more information than a long description. But on the other hand, the cases that are capable of elucidation by the graphic method are only a small section of the ground covered by mathematics. The usual device of a curve in which the co-ordinates are taken as variables, is capable of representing a function of a single independent variable, and nothing more. As a natural consequence, those who cannot form an adequate conception of even the simplest function of a single variable without recourse to the construction of a curve—and there are many such—cannot form any conception whatever of a function of two or more independent variables, for the reason that such functions cannot be represented or even indicated by the ordinary graphic method. The habit of leaning on graphic constructions always, and never learning to stand alone, is a great hinderance to the acquisition of a sound knowledge of mathematics. The person who can only think of a differential coefficient as the "slope" of a tangent, might reasonably be expected to make mistakes when he attempted to apply calculus to practical problems, and he does so frequently.

When a class of students once conspicuously failed in the application of mathematics to a problem in electricity, and got about as many different results as there were students, the professor, who is an eminent physicist, said they had not been properly instructed; they needed to learn physical mathematics. My own opinion is the reverse of this. What they really needed, was mathematical mathematics. The method of teaching mathematics by con-

crete illustration may be carried to such a length that the student does not develop any faculty for abstract reasoning at all. He is, therefore, unable to disentangle the essential or intrinsic features of a mathematical process from the extrinsic matter that has been added to facilitate the acquisition of the process, and frequently gets the idea, for example—as Professor Webster says in the preface to his "Theory of Electricity and Magnetism"—that certain theorems pertain to electricity, when they really are simply matters of geometry and analysis.

From time to time through all the history of engineering, there have been misapplications of mathematics which have furnished a plentiful supply of ammunition to those who do not believe in the utility of mathematics at all, and who are disposed to wage war against them. The most prolific source of such errors is the haziness of abstract mathematical ideas, and not, as so many suppose, too great abstraction; and a consequent inability to apply the abstract principles to concrete cases. One of the most frequent mistakes, if not the most frequent, in the application of the calculus, is in the application of the rule for maxima and minima. In every case, so far as I know, the mistake has arisen through the failure to observe exactly what is and what is not proved, in the solution of the equation considered as a purely analytical operation, and without reference to the particular application. That is to say, the solution answers this question, and this only. What values of the independent variables give a maximum or minimum value to the dependent variable or function? Many persons, however, after having obtained an expression for a maximum or minimum value, ignore the conditions under which it was obtained, and proceed as though it was absolutely true under all conditions. So long as there is any appearance of magic (as there frequently is to the uninitiated in the calculus), or even of mystery, in a mathemetical process, it is not sufficiently well mastered to be used without danger of grave error. When one understands a process as pure mathematics so well that the theory of it is perfectly easy and natural to him, there is very little danger that he will misapply it in practice.

The development of alternating currents has caused a demand for more mathematics in electrical engineering, including some form of vector analysis. This introduces the advisability of quaternions for electrical engineers. There is an old story of a Russian who had come into possession of a pair of candle snuffers, and who with childish pride, exhibited their use to his friends by snuffing a candle with his fingers in the old familiar way, and then carefully transferring the refuse to the receptacle in the snuffers. It has been ever thus with quaternions.

From their first introduction to the world by Sir William Rowan Hamilton, it has been predicted that they would be a tremendous power in physical research and discovery. When Maxwell's work appeared in 1873, quaternions were new to most physicists, and he said in his first chapter "As the methods of DesCartes are still the most familiar to students of science *and as they are really the most useful for purposes of calculation* (italics mine) we shall express ourselves in Cartesian form. I am convinced, however, that the introduction of the ideas, as distinguished from the operations and methods, of quaternions, will be of great use to us in the study of all parts of our subject." Later Heaviside says that quaternions are a powerful method in the investigation of quaternions, but not in any other investigation. He recommends vectors for physicists, and gives a vector method of his own. Some other physicists agree with him about quaternions, and they also agree that vectors are a good thing if you do not use Heaviside's method, and it may be here remarked that it was only vectors and not quaternions that Maxwell used even in the limited manner stated. Now comes Professor Webster, who says in his preface, "It is hardly necessary to say that vector methods have been used throughout, although the abbreviated notation of Hamilton and Heaviside has been little used."

If we leave out the matter in dispute, and retain that on which all these writers agree, we have, outside of nomenclature, one important process called in the modern euphonious language, vector addition, but which differs from the old composition of forces and velocities only in being a somewhat more general application of a principle. Other vector methods, such as rotation by multiplication, were also investigated by writers on imaginary quantity before Hamilton.

We are certainly snuffing the candle the old way, and we do not always bother even to put the ashes in the snuffers. One apologist for quaternions has said in effect, when his defense is boiled down so as to get the gist of it, that quaternions are all right, and we now only need a new kind of human beings who will think naturally in quaternions, when there will be surprising advances made. However, the kind of human beings who at present inhabit this globe accomplish more real work with the Cartesian methods than with even the modernized vector methods. as intimated by Maxwell in the passage above quoted, and no one seems to be making discoveries by means of quaternions.

The subjects of quaternions, vectors and imaginary or complex quantity are closely associated, and although the first does not seem to have accomplished much for physics or engineering, it would seem that the others are better suited for the requirements of those departments of knowledge. As before stated, vectors have long been in use under another name, and complex quantity seems to promise well in some cases. Mr. Kennelly first suggested the application of complex quantity to alternating-current phenomena, and Mr. Steinmetz developed the idea fully. I should recommend those who make a specialty of alternating currents to study this subject, but although the method is excellent when thoroughly understood, it is probably too abstruse for the general run of engineers.

Electro-Metallurgy of Copper.

900,000 ampere-hours of current would be required to deposit one ton of copper on a single cathode surface. In practice, many such surfaces are connected in series, thereby multiplying rate of deposition.

THE USES OF LOGARITHMIC CROSS-SECTION PAPER.

BY PROF. W. F. DURAND.

In an interesting paper on magnetic hysteresis by Mr. Ernest J. Berg, published in the December number of the AMERICAN ELECTRICIAN, there are given parabolic curves showing values of the 1.6 and of the .6 powers of numbers. Such values and all others of similar character may be so readily determined by logarithmic cross-section paper that a brief description of its use for these purposes may not be without interest.

Logarithmic cross-section paper as shown in the accompanying cut, is divided on each side into divisions such that the distances from the beginning of the scale are proportional to the logarithms of the numbers marked on the scale, instead of proportional to the numbers themselves. When, therefore, points are placed on such a sheet, the distances from the bottom or left hand edges represent the logarithms of the corresponding numbers. Suppose now that we have any equation such as:

$$y = ax^{1.6}$$

Then taking logarithms we have:

$$\log y = \log a + 1.6 \log x$$

Then if we agree to measure $\log y$ upward and $\log x$ to the right, this equation is simply a brief way of stating that the distance upward equals a constant quantity to start with ($\log a$) plus 1.6 times the distance measured to the right, and a point whose location fulfills these conditions will evidently give the value of y as a times the 1.6 power of x. Now the form of this equation relative to logarithmic paper is similar to

$$y = a + bx$$

for ordinary methods of plotting. As is well known, the latter equation on ordinary cross-section paper would produce a straight line. In like manner, then, the former ($\log y = \log a + 1.6 \log x$) will produce a straight line on logarithmic paper. That is, if a series of points are found fulfilling these conditions, they will all be found on a straight line, and this line will be inclined to the axis of $\log x$ at an angle whose tangent is 1.6, and will start at a height of $\log a$ on the left hand margin. If we wish simply a table of 1.6 powers, a is 1 and $\log a$ is 0, and the line starts from O and runs as shown at OA. To draw the line we may lay off any convenient distance as 5 ins. on the horizontal to B, and then lay up a distance equal to 1.6×5 or 8 ins. to C. Then the line, OC, will fulfill the necessary conditions. To use the line we take any number on the horizontal, and rising vertically to the line, we read off the value of its 1.6 power. Thus $2^{1.6} = 3.03$, $3.45^{1.6} = 7.25$., etc.

Another peculiar feature of this paper is that we may indefinitely extend the scope of the diagram simply by drawing a series of parallel lines as follows: the line OA gives the value of $x^{1.6}$ for all values of x from 1 to 4.22. Then we drop to this value on the lower line at D and draw DE parallel to OA. This carries the range to 10. Then coming across to F we draw FG still in the same direction which carries the range to 17.8, and so on as far as may be desired. Similarly by drawing from P the line PQ

downward in the same direction, we have the value of $x^{1.6}$ for value of x from 1 down to .237. Thus $.65^{1.6} = .50$, etc. Similarly the range may be extended as far as may be desired, and, of course, any numerical unit may be employed. In the same way the diagram for the .6 power may be drawn as shown in dotted lines.

In general, any series of lines drawn in the manner here described and at an inclination to the horizontal whose tangent is n will give values of x^n. Such diagrams are in fact equivalent to tables of unusual powers, and show at a glance the values desired.

As another illustration of such uses we may take the operation of laying down a steam expansion line for an ideal indicator card when the exponent of volume is not 1. Such curves are given by equations in the form:

$$P V^n = Const.$$

and for n various values are used as $\frac{10}{9}$, $\frac{17}{16}$, 1.2, etc. The values of p and v for the initial point are, of course, known and we have therefore,

$$P V^n = P_0 V_0^n$$

$$\text{or } P = P_0 \left(\frac{V^0}{V}\right)^n$$

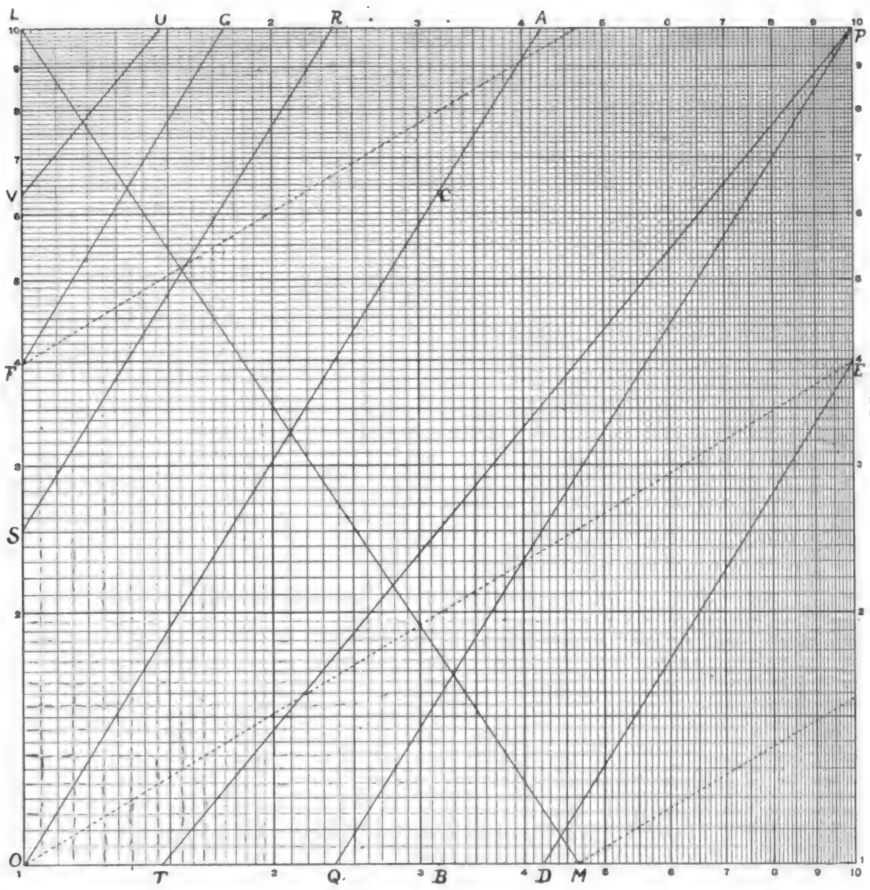
Assuming V greater than, V_0, the values of $V_0 \div V$ will be fractional and the values of this ratio to the nth power will be given by a line drawn from P downward at the proper angle, continued if necessary in the way shown above. Thus, in the diagram the line $P\,T$—$U\,V$ is drawn for $n = 1.2$. By the aid of this line the values of p are readily found and the diagram may then be plotted in the usual manner.

If the lines are drawn obliquely downward in direction as shown by $L\,M$, they will give the reciprocals of the powers given by those drawn in direction as shown above. In fact, it is seen that the tangent of the slope of such a line relative to the horizontal is (—), and hence such line should give values corresponding to negative exponents. Such lines correspond therefore to equations in the form:

$$y = x^{-n} \text{ or } y = \frac{1}{x^n}.$$

In the diagram the line corresponds to values of $x^{-1.5}$. Thus $2.7^{-1.5}$ or $1 \div 2.7^{1.5} =$ .225, etc.

These illustrations are only a few out of the many which might be drawn from the various fields of engineering, but they will serve to illustrate some of the simpler uses to which cross-section paper of this kind may be put. Such paper may be printed with a limiting error of less than one part in 500, and with ordinary care in drawing lines and on sheets 10 ins. square, the value should be read off with a limiting error of not more than one part in 200 or 300, which is quite accurate enough for most engineering purposes.



LOGARITHMIC CROSS-SECTION PAPER.

CONFERENCE OF ELECTRICAL UNITS.*

(Authorized Abstract.)

An ordinary meeting of electrical units was held last night in the new extension of the polar area.

The chair was taken at 7:46 by B. A. Volt, Esq., and the proceedings commenced with the singing of a hymn especially composed for the occasion by one of the Watts (D. Sc.):

How doth the little busy volt
  Increase the ampere-hours,
By exercising all the day
  His mighty storage powers.

How cheerfully he fills each cell,
  How neat he spreads the charge,
And labors hard in changing well
  Di-oxide to litharge. AMPERE.

The president then opened the meeting in the following speech: "Fellow units and constants—It is with the most sincere pleasure that I look back on the great progress we have made in the last few years, partly, no doubt, owing to the enthusiasm of our younger members, but chiefly, I think, to the high example of truthfulness and accuracy given us by my honorable friends, the *established standards*, whom I now see gathered around me." [The committee was composed chiefly of standards, who were seated round the president in a Gramme ring] After some further remarks, addressed chiefly to the younger members, the right honorable president proceeded: "Before I close this perhaps tedious address, I feel bound to pay a humble tribute of respect to my venerable and esteemed contemporary, the Siemens unit, little known, perhaps, to the new generation, since he has retired from active service; but let me tell you gentlemen, that but for him we might still be running along naked conductors in a helpless state of uncontrolled barbarity, scarce knowing whether we were quantities or differences of potential, instead of which we see everywhere, or nearly everywhere" (here the president looked pointedly at some young alternate volts who were sitting in series near the back of the hall), "order and law. I even hear with pleasure to-night that some of our most prominent members have organized a society for the conversion of foot-pounds. The first meeting will be held to-morrow night. Subscriptions are earnestly invited, and I am requested to add that contributions of cast-off insulation or disused lines of force will be thankfully received. I will now detain you no longer, but call upon my honorable friend, the Siemens unit, for a few remarks, by which all of us are sure to profit."

The Siemens unit, in a voice choked by self-induction, thanked the chairman for his kind references to him, and said: "I am now an old unit who have borne the current and heat of the day (the latter proportional to the square of the former), my insulation is getting thin and grey, and I now look forward to that quiet and peaceful ohm, 'where potentials cease from troubling and the amperes are at rest.' I would erg(e) you, then, to direct your energy along legitimate channels, eschewing the by-paths of modern Ferrantic enthusiasm. I am sure that my old and respected friend the continuous-current dynamo would never have so far lowered his efficiency as to consent to supply current to a tubular conductor for the base and vibrating purposes of high-tension and homicidal transformers. I would beg younger members to take pattern by him, and not to be led astray by the brilliant but erratic re-

* This clever and witty article was first printed in our English contemporary, *Electrical Engineer*, in 1890, and recently reprinted in the columns of the same journal. When the article was written, alternating currents were subject to much discussion, principally unfavorable, which made some of the references much more pointed at the time than, without explanation, they would appear at present.

sults obtained by that erg-destroying invention of the evil one, the alternate-current dynamo. My earnest prayer for each member present is that in times of trial and trouble, when short circuits and earths gather round your devoted head, you may be sustained and comforted by self-regulation, and that your observed characteristics may approach nearer and nearer to the ideal which has been plotted for your guidance and direction. I trust that the young alternate volts whom I see around me will forgive me if I have in any way hurt their feelings, but I feel strongly that a volt who has persuaded himself that the path of duty is a sine curve is cherishing a most fatal delusion, which must inevitably lead to the destruction of all that a unit holds most dear in this system and the next."

Here a young volt was led out by an elderly Ruhmkorff coil in a violent fit of hysteresis.

Scarcely had the honorable gentleman tottered to his seat when an alternate volt sprang to his feet and poured out his indignation in a torrent of words: "I wish to speak with the utmost deference of the honorable standard who has just sat down, but I cannot be calm. My potential rises when I think of the insults heaped upon me and my family by an antediluvian unit, however respectable. Why, I say, does he wish to hint that we are upstarts? The first dynamos who ever lived gave alternate currents. The natural conditions of the volt is to alternate, and yet we are despised and cried down, simply because we refuse to outrage nature by the artificial aid of a meretricious commutator. There is a violent prejudice against us; coiled resistances refuse us passage; many established instruments decline to measure us; there is even a base conspiracy amongst motors, who have united to lock us out, but I have no fear. Nature will triumph over foolish and malicious oppositions alike, and the glorious time will come at last, when potential will be infinite, conductors attenuated to a geometrical line, and amperes a thing of the past."

The next speaker was the ohm, who said she "could not but deprecate the tone of violent and high-tension personality which had been introduced into the discussion by the last speaker. His accusation was that the ohms were wanting in permittance and conductivity. She ventured to state that it had been demonstrated times without number that their coy resistance could be overcome by the steady attentions of a constant current, but she considered the fickle and false attentions, or rather persecutions, of an alternating current, whose value at the best was but a mean one, were but justly requited when they met with impedance." The speaker wound up an indignantly eloquent peroration with these noble words," "The manly and respectful attentions of a constant current we will receive with that courtesy which is their due, but the erratic, dishonorable and dishonoring seductions of a wobbling alternator we will never permit. No, sir, we have too much self-induction."

At this point the proceedings were interrupted by a violent disturbance created by an aged and respectable ohm who, amidst some confusion, screamed out that an ampere was crawling up her. He presently appeared at the top, and was then seen to be in a state of inebriation. The scandalized president just mustered sufficient potential to gasp out an enquiry as to how he got there, to which the ampere coolly replied that a volt had given him a "leg up," and there the matter had to rest; the refractory ampere could by no means be got down, as the back E. M. F. had just left the room.

After this it was found impossible to proceed, as all the ohms were tucking their skirts round their legs and screaming violently. Accordingly, the president, after one or two fruitless attempts to restore order, switched out the meeting.

THE JACQUES CELL DISCUSSION.

To the Editor of American Electrician:

I have not had time to follow the discussion between Prof. Anthony and Mr. Reed closely, but it seems to me that a brief statement of some of the facts in the case would tend to clear the air, so to speak.

First, carbonic acid gas does not escape from the Jacques cell in action. It produces, as a result of reactions, alkaline carbonate from the hydrate, oxygen and carbon. So far as the chemical reactions are concerned, the cell may be said to be a structure for manufacturing carbonate from hydrate and carbon. It requires therefore an equivalent supply of hydrate to the carbon consumed—two molecules of hydrate to each atom of carbon.

Second, the formation of carbonate goes on whether electricity be taken from the cell or not, and at nearly the same rate, so long as the air is passed into the electrolyte. The production of carbonate stops with the stoppage of the oxygen supply. This would indicate direct combination of oxygen with either the hydrate or the carbon. There may be a formation of a small amount of dioxide of the alkali metal which conveys the oxygen to the carbon. The action can scarcely be a combustion of the carbon, as carbon monoxide should then appear.

With the above facts in mind, we may make a comparison. Dissolve some copper in sulphuric acid to which is regularly added an oxidizing agent, such as hydrogen dioxide, and the product is sulphate of copper. If the oxidizing agent be supplied continuously, sulphate forms continuously. If while the copper is dissolving, a carbon plate be immersed in the liquid and a circuit completed from the carbon to the copper, electric energy may be obtained while the reaction goes on.

We have formed a voltaic couple. But during the solution of the copper itself without the battery organization, innumerable, almost infinitesimal, couples were in action and current flowed in tiny circuits—local action was occurring. When the carbon plate was added and an external circuit was established, the circuits were simply lengthened or the electric energy in part transferred to the longer outside circuit, just as the magnetization of a bar of iron or steel by any means may be regarded as the opening out and lengthening of exceedingly small magnetic circuits existing within the mass before magnetization.

Now substitute the carbon of the Jacques cell for copper in the above-mentioned case, sodium hydrate for the sulphuric acid, air or oxygen for the oxidizing agent, and an iron negative electrode for the carbon plate used with the copper, and it is difficult to see much difference in the general results of either combination, except that the reactions in the latter case demand an elevation of temperature above that at which the reactions in the former case of solution of copper occur. The energy given out may, in either case, be all heat within the cell or partly electric energy in an outside circuit, and the source of the heat or electric energy is evidently the combination to form a stable chemical compound—in one case copper sulphate and in the other sodium carbonate.

The precise theory of action may be somewhat complex and difficult to settle, but no theory can change the facts as they exist.

We might have used zinc instead of copper in the above illustration, but as with copper the action ceases when no oxiding agent is supplied and would not stop with zinc, the analogy to the Jacques cell is more perfect with the copper reaction.

Lynn, Mass. ELIHU THOMSON.

To the Editor of American Electrician:

In my last letter upon the Jacques cell I said in effect that oxygen in some way comes into electrical connection with the iron electrode, combines with the positive ion of the electrolyte at that electrode, and is the medium by which the current reaches that electrode and so passes out of the cell.

This can have no other meaning than that the energy furnished by the union of the oxygen with the positive ion goes to make up the sum of electrical energy that appears in the circuit. In support of this view I called attention to the fact that the current produced by the cell is greatly increased the moment the flow of oxygen begins, and that much more oxygen is *absorbed* by the cell when the circuit is closed than when it is open. I further called attention to the analogy furnished by the Grove gas cell, where it is well known and has been known for more than fifty years that the oxygen introduced, by entering into combination, furnishes electrical energy to the circuit. I also called attention to the zinc-platinum cell, where without oxygen, the E. M. F. was .7 volts, with oxygen 1.5 volts. I said in regard to these cases, which are entirely analagous to the Jacques cell in the function performed by the oxygen, that the energy of the union of the oxygen with the hydrogen is certainly added to the electrical energy of the cell.

In the face of all this Mr. Reed says in his reply: "Prof. Anthony now admits that this reaction between the oxygen and the reduced iron" (ion) "cannot evolve electrical energy. It can evolve only heat energy," and further on "that" (energy) "furnished by the union of the oxygen with the positive on of the electrolyte, now appears by his own admission to be only a source of heat." I leave it for your readers to judge whether Mr. Reed fairly represents my position as

indicated by my letters from the beginning of this correspondence.

I see no benefit to be derived from prolonging this discussion. My position is and has been all along, that the oxygen acts as a depolarizer, that the energy of its combination with the positive ion—combination that occurs *at the iron electrode*, not around the bubbles straying through the cell—furnishes electrical energy and not heat.

In support of that view I have adduced facts and analogies which Mr. Reed has never made the slightest attempt to explain away. Intead of this he has by misrepresentation, by reading into my letters statements that were as far as possible from my real views, endeavored to create the impression that I was holding to some absurdity, or that my views coincided with his own. Until he meets my arguments and any illustrations fairly, I nave nothing further to add.

As to Mr. Reed's theory, I can see no warrant for it. There is not necessarily in a Jacques cell any hot or cold junction where iron can be oxidized and reduced. If it were oxidized and the energy transformed into heat, the second law of thermo-dynamics teaches that only a fraction of that energy could be recovered as energy of any other form. There is no reason for saying that heat and not electric energy is evolved by the oxidation of the ions in the Jacques cell, that does not apply equally to the gas battery, or the zinc platinum battery with a gaseous oxygen depolarizer, or for that matter to any two-fluid battery containing an oxygen depolarizer.

Prof. Thomson's views as expressed in his letter appearing in this issue, accord exactly with my own as to the action taking place in the Jacques cell.

His statement that the formation of carbonate goes on at nearly the same rate whether electricity is taken from the cell or not, only shows to my mind that in the cell as usually constituted, there is an enormous amount of local action. I do not know how the original Jacques cell was constructed, but the cuts I have seen represent the oxygen as being introduced at the bottom and bubbling up around the carbon. If the object were to promote local action, no better scheme could be devised. It is like making up a gravity cell with the copper and copper sulphate at the top, and the zinc and zinc sulphate at the bottom. In my view, the oxygen should be as carefully kept from the carbon in the Jacques cell as is the depolarizer in two-fluid cells from the zinc. It should be brought into the top of the cell, or if a porous partition were possible of application, it might be separated in that way.

I believe, if such precautions were taken, the carbonate formed would be found to be very nearly the equivalent of the current, and that its formation would practically cease when the circuit was open.

Experiments of my own to which I referred in my last letter, and in which I kept the oxygen which bubbled through the cell away from the carbon, show that much more oxygen is *consumed* in the cell when the circuit is closed than when it is open, and the carbonate formed must be in proportion to the oxygen consumed.

W. A. ANTHONY.

New York, N. Y.

NOTES.

A Pioneer Electric Light Plant.—The second incandescent electric lighting plant in the United States was installed at Dolgeville, N. Y., in 1879. The original Edison machine (No. 2) is still in service and apparently good for many years yet to come.

Insulated Wire Combination.—A movement is on foot to form a combination of all the larger rubber-covered wire manufacturers in the United States, with a view to ameliorating the present situation with respect to ruinous competition. Those interested claim that the proposed combination will result in reducing expenses to such an extent as to give to manufacturers a fair profit without advancing prices to the consumers.

Brussels Exposition Awards. — American manufacturers carried off the honors at the recent Brussels exposition in the section of machine tools, receiving a majority of all the medals awarded. The "Grand Prix," or highest possible distinction, was awarded to but three concerns—The Pratt & Whitney Company, the Brown & Sharpe Manufacturing Company, and a Belgian firm. American firms also received nine of seventeen gold medals, nine of seventeen silver medals and all the bronze medals.

Electricity in Medicine.—An English contemporary relates that a lunatic believed a doctor in Sheffield had power to transmit poison by electricity into his food, and that nothing but shedding human blood would relieve him of the danger. The man was arrested while attempting to apply the remedy. Our contemporary adds that transmitting poison electrically is a new idea, but at the same time suggests to some extent the Mattei remedy, advocated by W. T. Stead, of swallowing green, pink and blue electricity.

A Large Monocyclic Installation.—A notable change is about to be made in the plant of the Omaha Thomson-Houston Electric Light Company, which is to be entirely modernized. A considerable number of smaller machines are to be replaced by three monocyclic alternators, each one to be directly connected to a compound condensing McIntosh & Seymour engine. These alternators will be revolving armature, 43-pole machines, each of 300-KW at 150 r. p. m. They will be used to furnish current to an extensive system of three-wire secondary mains fed from large transformers.

High Efficiency in Steam Working.—Mr. George W. Barrus recently made a measured feed-water test of a 1000 HP cross compound Greene-Wheelock engine at Grosvenor-Dale mills, Grosvenor Dale, Conn., which gave an efficiency of 11.39 lbs. of feed-water per indicated horse power per hour. The boiler pressure was 150 lbs., the vacuum 26.6 ins. and the number of r. p. m., 80. The indicator cards showed the proportion of feed-water accounted for at release to be 80 per cent. in the high pressure cylinder and 70.4 per cent. in the low pressure cylinder. A fourteen hour test was also made with the Manning boilers of this plant, which showed the consumption of coal per I. HP to be 1.18 lbs. per hour. The evaporation from and at 212 degs. was 12.208 lbs. of water per pound of combustible, or 13.343 including the effect of the Green economizer with which the plant is fitted.

The New Maxim Lamp.—Mr. Hiram S. Maxim in a letter to the London *Electrician*, furnishes some information in regard to his new lamp, which several months ago was made the subject of a sensational cablegram. After referring to his misquotation by a reporter, he said that he has been attempting to produce a iamp in which a very high resistance might be obtained with a short and thick filament; also to produce a filament which will stand a higher temperature than those ordinarily used, as it is well known that a slight rise in the temperature greatly augments the light given in proportion to the current used: The preparation, however, of the carbon and other materials which form the filament requires a very expensive apparatus, but the cost, of the finished filament —excepting first cost of plant—is no greater than with the ordinary lamps. He has tested the new lamps in competition with all the best lamps he could find, and states there is no question but what they show a very marked saving in electrical current, and this, of course, is the object aimed at after all. A 42-CP lamp gave an economy of considerably less than 2 watts per candle power, and after running two months rose to 52 CP, but when last tested had dropped to 41 CP. Mr. Maxim adds that he has not decided as yet whether to keep the process a secret or to patent it.

Electrical Misinformation.—Almost every mechanical periodical has a department devoted to "practical electricity," in which, with rare exceptions, the electrical facts given, when not entirely wrong, are so distorted as to be unrecognizable by the electrician. In one journal before us, directions are given for installing a 72-ampere 110-volt plant—the voltage of 110 being recommended because "that pressure gives the best results and the least line loss." The sizes of conductors are determined by means of a table of "Carrying Capacities of Wires," the writer adding "The sizes of wire to be used might be figured out according to Lord Kelvin's rule and Ohm's law, but in a plant of this size it is usual to put in as small a wire as the underwriters will allow!" The reader is cautioned that "the fuse wire to be used should be regulated, not by the number of lamps, but by the carrying capacity of the smaller wire;" from which we infer that if a main carries fifty lamps and a branch five, the main should be fused for five lamps. Another mechanical periodical informs its readers that "For a three-phase motor four wires are sufficient, as this gives three wires for the three currents to reach the motor, and one through which the whole three can return. The currents returning to the generator all mixed up in the return wire, do not interfere with the operation of the apparatus, as the generator sifts out the respective currents, so to speak, and sends each one into its proper channel."

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In announcing the retirement of Mr. E. L. Powers from the management of the AMERICAN ELECTRICIAN, we are glad to say that he will continue in the electrical publishing business, with which he has so long been identified, though in somewhat different lines. Mr. Powers has been prominently connected with electrical journalism for the past ten years, having founded *Electrical Industries*, to which the AMERICAN ELECTRICIAN succeeded. No one in the electrical field has a more extensive and loyal circle of friends, all of whom, we feel sure, will be glad to unite with us in wishing Mr. Powers the success which his marked ability and sterling integrity so well merit.

Electric Heating.

An article in another column describes several of the many special uses to which electric heating is being applied, and which are becoming more numerous every year. Where heat is required to be highly concentrated, as in the electric furnace, or isolated, as in many tools used in the arts or in cooking, electric heating possesses undeniable advantages. That it will now be used for the general heating of houses is, however, entirely out of question, as a simple calculation, based upon the amount of heat available from 100 lbs. of coal burned in a furnace, and the equivalent in kilowatt-hours of electrical energy will show. The unwise claims made on this score have undoubtedly done much to retard the development of electric heating in the field where it has real commercial advantages. As a novel method of electric heating soon to be placed on the market, we may mention a fan, the blades of which are electrically heated, thus enabling a current of warmed air to be sent in any desired direction.

Engine Governing.

The article on ways and means of testing engine governing elsewhere in this issue is another indication of the care now being taken to arrive as near perfection as is possible in a vital requirement of modern engines used in connection with electrical machinery. The practice, now becoming common, of operating from the same circuit incandescent lamps and electric elevators, with their widely fluctuating demand for power, renders it imperative that engine speed variations, even under these severe conditions, shall be so slight that there shall be no noticeable flicker in the light. It is seldom practicable for the engine manufacturer to assemble his machine and that of the generator manufacturer in his shop, and test there by throwing load off and on as would occur under service conditions; and even if it were, it would be difficult, if not impossible, to locate any fundamental trouble in the design of the governor by the old tachometer methods. An accurate recording of the variations in speed, both as to amplitude and duration, is needed to give data for intelligent action. The method of obtaining these records varies in different shops, but it may be safely stated that all are capable of improvement.

In this connection it is interesting to note the extreme accuracy with which the modern governor will handle the load. Even in some of the older types, the controlling of speed within a variation of 1 per cent. was frequently attained; one of which we have knowledge had the remarkably fine record of one-third of 1 per cent. variation from full to no load, and ½ per cent. from light to full load. The inertia type of governor which is now so rapidly coming to the front, seems to be able to duplicate this peformance with comparative ease—an achievement of which designer and engine builders may well be proud.

Water Rheostats.

In testing work of a commercial nature where resistance is required for the regulation of current, the water rheostat in most cases is the handiest and least expensive form of resistance to use. For large powers, indeed, it is the only practicable resistance available, any other form being so expensive as to render its use out of question. Heretofore there has been little or no literature on the practical application of the water rheostat, and consequently the articles in other columns giving such information perform a much needed service.

To those not having had experience with water rheostats in the absorption of large quantities of electrical energy, the small amount of surface required will doubtless be surprising. In tests quoted this was as small as one square foot of immersed surface for 400 amperes of current; the voltage being 550, this corresponds to 300 HP per square foot of surface. At this rate of dissipation the amount of heat developed is sufficient to evaporate 12 lbs. of water per minute, or an amount about 300 times greater than that evaporated from the same area of boiler heating surface. Though this heat is distributed through the volume of water between terminals, it is yet sufficient to cause a considerable ebullition, which results in some unsteadiness in the current, though not sufficient, with proper arrangements, to be of moment in practical testing.

It will be noted that no precise indications can be given as to the quantity of salt or acid to introduce into the water to modify its resistance. As the only object of the introduction of any substance is to lower re-

sistance, it is probable that some organic matter may be used for that purpose that will have less deleterious effect on the plates than an acid or salt, the quantity to be determined by trial, as in the case of the latter. Owing to the absence of any considerable electrolysis, the water rheostat, it may be remarked, is much less troublesome in its action when used in an alternating current circuit.

Primary of Induction Coils.

In the remarks on the primary of induction coils which appeared in these columns last month, the effect on the time constant of reduction of the resistance of the coil was not referred to. The time constant of an inductive circuit is the ratio of the self-inductance to the resistance, and is a measure of the rapidity with which such a circuit is charged and discharged. If, therefore, the self-inductance remains constant and the resistance is decreased, the time of charge or discharge is increased. This follows from the fact that on introducing an E. M. F. in circuit, the counter inductive current is stronger the less the resistance of the circuit; and in removing an E. M. F., the inductive current, representing the energy stored up in the coil, continues longer the less the rate at which it is dissipated—that is, the smaller the resistance.

To apply these principles to the case of the primary of the induction coil, we can neglect the "break," as the resistance of the arc is so great in comparison with the resistance of the coil that, practically, the latter does not enter. Consequently, the length of spark will depend entirely upon the inductive E. M. F.; and to obtain the least length of spark and therefore the most rapid discharge of coil—which leads to the highest secondary E. M. F.—the self-inductance of the primary should be a minimum, or it should have the fewest possible number of turns.

In the case of "make," the quickest establishment of the strength of the coil is desired. The resistance will vary with the number of turns of the coil but, for the same strength of coil, the self-inductance will also vary with the number of turns. Consequently, where there is no external resistance, the rapidity of "make" is not increased by reducing the inductance, nor is it lessened. An important conclusion from this is that there is an advantage in adding non-inductive resistance in the external circuit of a primary coil, since such resistance will increase the rate at which the coil is charged and, if considerable in amount, will also decrease the time of discharge. A coil with a properly designed primary should therefore work better on an electric light than battery current, owing to the large amount of non-inductive resistance necessary to be introduced in the former case.

The Jacques Cell Discussion.

In the present issue Prof. Elihu Thomson furnishes some facts concerning the working of the Jacques cell, together with an analogy rendering more simple an understanding of its probable action. According to the view of Prof. Thomson—a view evidently based upon a careful study of the cell—the action in the Jacques cell can scarcely be called a combustion of carbon, as carbon monoxide in that case would appear. What does occur is the formation of an alkaline carbonate, which formation gives out energy that may be all heat within the cell or partly electric energy without the cell.

This process is far from the one laid down by Ostwald and others as being involved in the direct production of electricity from carbon, which requires that such process must be by oxidation without transformation of any energy into heat, without the electrolyte being affected and without the production of waste products. None of these requirements appear to be fulfilled in the Jacques cell, notwithstanding which it has been heralded far and wide as a solution of perhaps the greatest problem presented in electrical science. No explanation was offered of its action, the presence of heat, oxygen, carbon and an electrical current being apparently considered sufficient to sustain the claim. It is true that data showing a high efficiency have been offered, but these are valueless, for the reason that they were obtained by casting aside great losses as not intrinsic to the action of the cell, thereby transforming a great disparity between input and output to a high efficiency.

The discussion between Professor Anthony and Mr. Reed has turned upon the action within the cell without particular reference to the claim that it produces electricity direct from heat in such a manner as to involve a high efficiency. We regret the misunderstanding which has arisen in this discussion, which has doubtless followed from the complicated nature of the actions involved and the newness of the ground covered, the sparsity of pre-existing knowledge allowing a wide field for difference of opinion. The claim of Professor Anthony that the oxygen in the Jacques cell acts as a depolarizer, and that of Mr. Reed that the action of the cell is thermo-electric, have, however, one inference in common—that the Jacques cell does not fulfil the requirement of a transformer of the energy of carbon direct into electricity.

Mathematics.

The article by Mr. Townsend Wolcott in another column on "Mathematics for Engineers" will be found interesting even by the reader who cares nothing for mathematics. No branch of learning is perhaps so full of fads as mathematics, and Mr. Wolcott exposes some of these in an unsparing manner. His advice to engineers relates less to the quantity of mathematics to learn, than to the manner of learning what he does select. Undoubtedly the latter point is the more important one, for a person may pursue an extended course of mathematics and yet learn—or, at least, be able to use—but a little part of it.

The amount of mathematics necessary for one to know would seem to depend entirely upon the use to be made of it. If merely for the working out of problems that come up in practical work, then arithmetic, simple algebra, geometry and trigonometry are sufficient. This, however, represents but one of the uses of mathematics, a far more important one from another standpoint being its function as a species of shorthand, and as a mechanical process of reasoning. To one, therefore, who wishes to follow the progress of a science through its literature with the least labor, a more extended and intelligent knowledge than the above is required. In this case mathematics enormously reduces the labor of understanding many subjects through condensing in symbolic form reasoning, sometimes in a single expression, reasoning that otherwise might occupy pages for expression, with consequent difficulty of keeping in mind and corelating the different steps.

With even an elementary knowledge of the calculus, the understanding of alternating currents is immensely simplified through this shorthand method of conveying in a few characters a vast amount of information, otherwise, in this case, difficult to seize on account of the idea of rates entering, which idea in the calculus is always kept before one by the symbolism employed. If one wishes to enter upon the etherial theory of electricity, then another system of symbolism—that of vectors or quaternions is necessary—not because calculus, vectors or anything of a similar nature are absolutely necessary to a physical understanding of that or any other subject, but because their use as a tool vastly facilitates the acquisition of such understanding.

CONSTRUCTION OF AN ELECTRICAL TESTING SET.—III.

WINDING AND CALIBRATING.

BY JAMES F. HOBART, M. E.

With the box made and the base-board and brass work heretofore described, all fitted in place, the next step is to wind the galvanometer, for this instrument is to be used in calibrating or adjusting the resistance coils of the box.

No. 36 (B. & S. gauge) single silk covered wire will be used, copper of course, and almost ¼ lb. can be wound upon the brass galvanometer spool or frame. Solder the inner end to the brass spool, and be careful not to use acid in so doing. Use rosin, and avoid trouble in the future from the possible detaching of the inner end of the coil. The outer end of the wire is to be attached to the brass plug in the middle of the galvanometer box bottom. The easiest way of doing this is to let the plug come through and rivet over a strip of brass, which extends out almost to edge of box bottom. A screw put through the brass into bottom of box, makes a good binding arrangement, and the wire may be slipped under the brass and the screw will hold it there.

If a lathe is handy, the galvanometer may be wound therein. If not, wire a bit of wood to the hand wheel of a sewing machine. Screw the galvanometer box to the wood by means of a single wood screw and a washer. Tie a piece of heavy wire, or ½ in. round iron, in an upright position to the back of a chair. Slip the spool of wire on it, and go ahead with the winding. The box or spool being rectangular, the wire will jerk off the spool as it winds on the box. Danger of breaking may be obviated by holding the wire in both hands, letting that portion between them form quite an angle with the wire leading to the spool, which should be placed 3 or 4 ft. behind the winder as he sits at the machine. By letting the hands move to accommodate the jerks of the wire, the spool may be made to run smooth. The galvanometer will have a resistance of about 1000 ohms when wound, and with one cell of badly run-down Le Clanche battery, gave a deflection when short-circuited with 1 ft. of No. 16 copper wire, a resistance of about .004 ohm. Make sure that the spring connections have good contact, and that the bearing surfaces thereof, both on the springs themselves, and on the galvanometer box, are bright and clean, before putting them in place.

The winding of the coils themselves may

WINDING FOR TESTING SET.

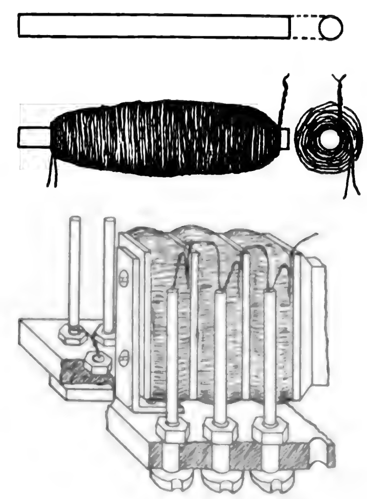
Battery	10 coils,	1 ohm,	=	10 ohms.
Mult. and Div. Coils	2 "	1 "	=	2 "
	2 "	9 "	=	18 "
	2 "	90 "	=	180 "
	2 "	900 "	=	1800 "
Units	10 "	1 "	=	10 "
Tens	10 "	10 "	=	100 "
Hundreds	10 "	100 "	=	1000 "
Thousands	10 "	1000 "	=	10,000 "

Ohms.	Length Single.	Length Double.
1	0 ft. 1.544 in.	0 ft. .772 in.
9	0 " 13.896 "	0 " 6.948 "
90	11 " 6.96 "	5 " 9.48 "
900	115 " 9.6 "	57 " 10.8 "
10	0 " 15 44 "	0 " 7.72 "
100	12 " 10.4 "	6 " 5.2 "
1000	128 " 8 "	64 " 4. "

Total number of ohms required, 13,120.

now be calculated and put in place. The above table gives the calculations as made for winding my own instrument. I used No. 36 wire throughout for both the small and the large coils. If desired, larger wire could be used to advantage (in handling and adjusting) on the one ohm coils, but as many of these instruments are to be constructed at a distance from any source of supply, I figured to use the same size of wire throughout the instrument.

Resistance of No. 36, 18 per cent, German silver wire, single silk covered, 1000 ft., = 7,770,816 ohms, therefore, 1 ohm = 1.544 ins, of wire. Total quantity of wire required, 1.688 ft., weight, 2.032 ozs. This does not include any length of wire for connections, and it is the calculated length, resistance, etc. We will verify the lengths later, before cutting up all the wire. It is safe to purchase 3 ozs. of the German silver wire and 4 ozs. of the copper wire for the galvanometer. In addition to this, a few feet of No. 16 copper wire will be required for the connections in the box, 50 ft. will be ample for the con-



FIGS. 59, 60 AND 62.—COILS AND CONNECTIONS.

nections, and for a low resistance bridge for use in adjusting the box. This wire will weigh a little less than ½ lb.

The table of length given above, is calculated from tables published by a large manufacturer of wire, but it is impossible to always make the smaller sizes of wire to agree with the standard. Different lots may have a greater resistance, etc. To obviate this difficulty, a piece of wire measuring 1 ohm, at 70 degs. F., will be sent out with each set of blue prints ordered of the writer. Or if any constructor of the set prefers, he may send a sample of the wire he proposes to use, and an ohm thereof will be tested out and returned to him as a standard to wind the box by, All communications relating to the construction of the box, should be sent to James F. Hobart, 230 Eleventh Street, Brooklyn, N. Y.

The wire used on my box, although purchased from the firm issuing the table used in calculating lengths, measured more than the stated resistance. A 100 ohm coil wound with 12 ft. 10.4 ins; of No. 36 wire, had a resistance of 116.88 ohms. A proportional part would be: 100 : 116.88 : : 12′, 10.4″ : 11′ 0″. The half of this would be 5ft. 6 ins.; therefore, if pins are driven into a bench that distance apart, a piece of wire can be doubled around the pins, and cut off, leaving 5 or 6 ins. for connection and adjustment. The double length of wire is then wound on the resistance spools and forms one of the 100-ohm coils.

The 1000-ohm coils are wound in a similar manner, putting ten nails side by side, and winding the ten double lengths up together. This forms a non-inductive coil. After the ten double lengths are strung upon the pins (I used wire nails with the heads removed), thread a small string or stout thread into each loop, or bight, and lift them off the pins. Winding the threads upon the spool will start the wires on all right, and if bits of paper are placed over each loop, there will be no short-circuiting at these points. Papering should also be done at the other end of the doubled wires. One of these loops should be cut apart and soldered to the contact plugs (Fig. 7.), as shown by Fig. 62, which also shows the method of connecting the contact bars with the rows of plugs.

Fig. 61 shows the manner of winding up the coils, as above described, and showing one of the loops cut open for connecting. This leaves the original ends of the wire free for adjusting the resistance, as will be described later. Fig. 59 shows one of the pieces of dowel rod, mentioned in the last chapter, and Fig. 60 shows one of the 900-ohm coils wound upon the rod. These coils may be wound up straightway, as shown in the engraving, or they may be wound doubled, as the graduated coils were put together. I found this way preferable, but when winding in a lathe, the straightway method may be preferred by some.

The winding of the 1-ohm and 10-ohm coils will be rather delicate with No. 36 wire, but I had no trouble in doing it, except the exercise of considerable patience. In another box, constructed from these drawings, No. 28 wire was used for the 1-ohm and the 10-ohm coils. As yet, I have seen nothing better in one than the other, except in the adjusting of the coils, where the No. 28 wire is the easiest to handle. In putting on the 1-ohm coils with No. 36 wire, some pieces, 4 ins. long, are stripped of their insulation, doubled in the middle, and the bend soldered to the end of a plug (Fig. 7). The length of a 1-ohm coil will be 11 ins. × 12 ins. ÷ 100 ins. = 1.32 ins. One-half of this is .66 in., or just about ⅔ in. Then, if the wires from two adjacent plugs be twisted together until the free part is ⅔ in., the resistance will be very near an ohm.

The 10-ohm coils may be made in the same manner, only the insulation should not be removed from the wire, only for a space enough for soldering. Then the 10-ohm coils may be twisted up to a length of 6.6 ins., after having first been given a turn around the rectangular spool. After being tested,

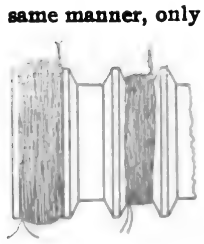


FIG. 61.—COIL.

these coils may be attached to the spools by dropping a bit of hot sealing wax on them and pressing to the spool until the wax sets. This should not be done until after the coils have been adjusted. If it is desired to temporarily fix the wires when winding to hold them out of the way until tested, use wax from a common paraffine candle. This will hold the wires, yet they

may be easily pulled up for adjustment and soldering.

It must be kept in mind that this measuring will not do unless the wire has been tested, and it is known that it has a resistance per foot according to the figures given above. Perhaps the lot of wire may run 12 ft. to 100 ohms. Then, a different measurement of length will be necessary all through. Having got the graduated coils all wound,

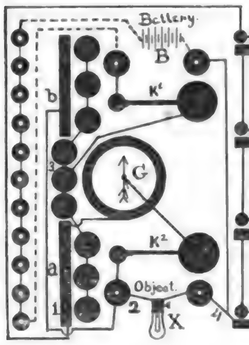
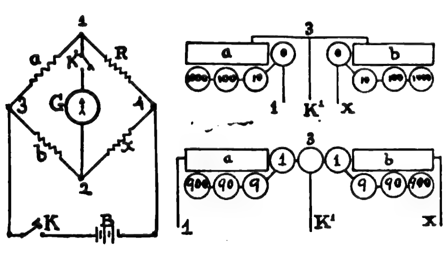


FIG. 63.—CONNECTIONS.

the box should be connected up, before the spools are put in place.

The connections are shown very plainly by Fig. 63. The principle of the bridge may be more readily understood by reference to Fig. 64, where the points are laid out and numbered 1, 2, 3 and 4. The various resistances are marked *a*, *b*, *R* and *x* in both figures. By referring to Fig. 64, the various connections may be readily followed in Fig. 63. In soldering on the wire connections, remember that the base board is bottom side up, therefore everything is reversed from what it appears in the drawing. It is well to put a piece of paper over the blue print, hold them against the window, and trace a reverse for use when making the connections. For this purpose, I used the bare No. 16 copper wire, and taped it heavily between the various soldered connections.

The little coils at the left are for resistance in the battery circuit when necessary, and I simply loop a wire over the contacts, leaving



FIGS. 64, 65 AND 66.—THE PRINCIPLE.

about 1 ohm between. It is not necessary to measure these coils. Having all the connections made, and the coils soldered in place, it is necessary to adjust them before the twisted ends, Fig. 61, are finally soldered. To do this adjusting, a coil of one ohm is necessary to work from, and a reflecting galvanometer and a low resistance bridge are also necessary.

Fig. 67 shows an arrangement that may be used. The galvanometer has a bit of looking glass fastened in an upright position to the needle by means of a little sealing wax. A small lamp, *s*, is placed behind a board screen, *t*, through which a narrow slit, *u*, permits a beam of light to pass. A reading glass, or an opera glass lense is placed at *v*, on the board, *x*, upon which the galvanometer, *w*, is placed. Short legs may be placed under this piece of board so the bit of mirror comes level with the flame of the lamp. The apparatus is so adjusted that the beam of light passing through the lense, is reflected back to the wooden screen at *y*. Then when current passes through the galvanometer wires *k* and *l*, the beam of light will be moved. The magnet, *z*, keeps the needle to zero.

Fig. 67 also shows the form of low resistance bridge which I arranged for adjusting the coils. It consists of a piece of board 1 in. thick, 12 ins. long and 6 ins. wide. Six ½ in. holes, *a*, *b*, *c*, *d*, *e* and *f*, were bored as shown, about ½ in. deep. Wires, *m*, *n*, *o*, and *p*, were put through awl holes into *a*, *b*, *c* and *d*, and fastened to tacks, one of which was driven in the bottom of each hole. Wires, *k* and *l*, were fastened in the same way, and carried to the galvanometer, which was placed on a shelf out of the way of any disturbance. Wires, *q*, *r*, were put into holes, *a* and *d*, and carried to a battery, passing through a push button in place of a circuit-closing key. The more cells, the better. Make up the chloride of silver battery for the box, and connect up all of the cells.

Wind up some coils on the dowel rods, *g*, *h*, *i*, *j*, and bring the ends into the holes as shown, passing the wires through awl holes. The insulation must be removed where the wires pass into the holes. Coils *g* and *j* must be alike, as also must *h* and *i*. I made *g* and *h* about 500 ohms, and *h* and *i* about 50 ohms each. It is only necessary that *i* and *h* be large enough to prevent the battery from heating the small 1-ohm coils when testing them, and the 100 ohms will do this all right.

With the wires all adjusted, fill the holes with mercury and connect *m*, *n*, and *o*, *p*, together. Close the battery circuit, and shorten or lengthen the coils, *g*, *h*, *i*, *j*, by pulling the ends of the wires through the mercury, until the galvanometer gives no deflection. Then fasten the coil wires with sealing wax, and the bridge is complete. One of the wax fastened wires is shown at *e*.

The pivot of the galvanometer must be kept very sharp in order to obtain good results. A high grade galvanometer could be used with the bridge shown in Fig. 61, and the coils adjusted down to any required degree of fineness. With the pivot galvanometer, weighted with two bits of mirror—one on either side of the pivot in order to balance—I was able to test up ten 1-ohm coils, which, when measured on a high grade bridge, stood at 10.005 ohms, or in error about one-half of 1 per cent. As many of the "store" instruments have an error of nearly 1 per cent., the working of the home-made adjustments was not so bad.

The 1-ohm resistance wire is shown at *m*, *n*, with the thick wire legs inserted in the mercury cups *a* and *b*. The coil to be adjusted is connected to the plugs *o* and *p*, which are in turn, connected into the cups *c* and *d*, by thick flexible wires. When adjusting the bridge, the plugs *o*, *p*, were placed close together in two of the plug holes in the box, so they would be short-circuited by the heavy bar, and yet have the contact resistance included in the balancing of the bridge. This eliminated a good deal of the error due to contacts. It is absolutely necessary to keep the plugs and the contacts perfectly clean. The fingers must *never* be touched to the metal contact part of a plug, or trouble will arise, and the correctness of the coils be damaged by poor contacts.

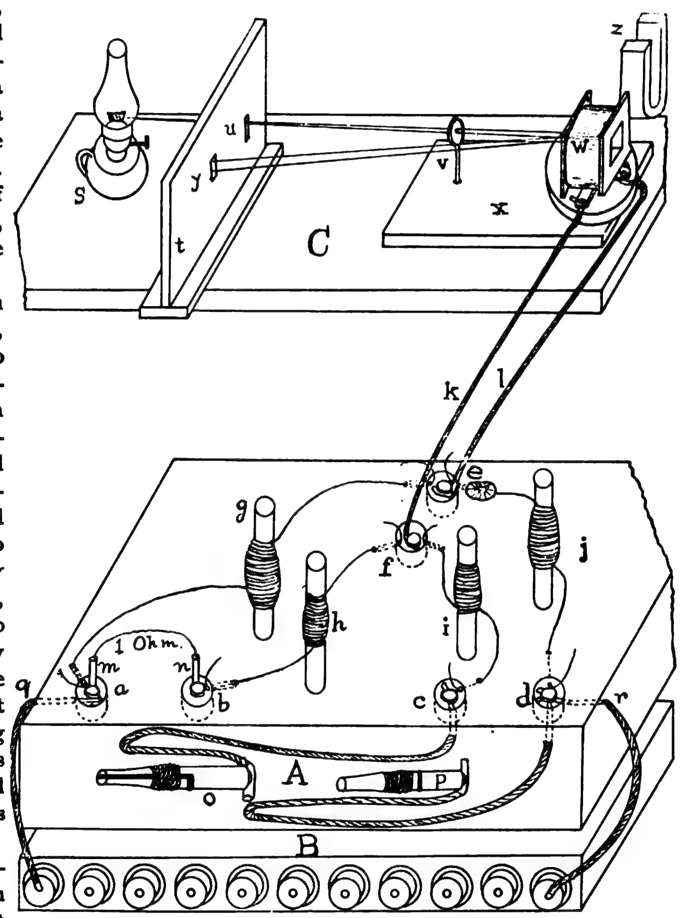


FIG. 67.—RIG FOR ADJUSTING COILS.

The plugs *o*, and *p*, are split, so that only one side is in electrical contact with the coil contacts. To make these plugs, I file them up to fit and run a hack-saw into the end about 1 in. The slot thus made was run full of sealing wax, then a stout twine was bound on, and also coated with hot wax. On cooling, the plug was found to be very solid, and the saw was run in at the side, cutting off the piece altogether. A wet rag was wound around the end of the plug, and the second cut filled with hot wax. The testing can be done with one split plug, but two are very handy, and will pay for the amount of time it takes to make them.

By putting in the plugs, with one hole between them, any coil can be tested and adjusted by twisting up the wires until the galvanometer shows no deflection. The regular keys are not shown in Fig. 67, but something of the kind is very necessary in order to work the bridge, therefore I put an open push button in the circuit from q, to the battery, and two more pushes in the circuit, $k\,l$. These buttons were rigged for either open or closed circuits, and by pushing either of the buttons, current could be sent in either direction through the galvanometer. This I found to be a strong point, as the galvanometer was necessarily a little sluggish, owing to its construction, when the coils were nearly balanced. Then, by pushing first one, then the other of the buttons, the visible deflection of the spot of light could be doubled by giving it a movement in either direction. The connection in the push buttons was merely to connect the wires from the mercury cups to the springs in the buttons, then fork each wire from the galvanometer, and attach one of each to the make and break contacts in either button. As these coils are all non-inductive, the galvanometer key may be closed first, then upon closing the battery circuit, the rush of current gives a more noticeable deflection to the spot of light—but this don't always work unless the resistances are all non-inductive, as they are in this case.

In this manner, all the coils must be worked up. A good deal of time and patience will be required, and you will know a good many things after a good accurate box has been worked up, that you did not know before doing it. After two coils have been tested up, they may be plugged in series, and a piece of wire balanced against them. After all the one-ohm coils have been adjusted, they may be tested in pairs against the bit of wire thus measured, putting it in the cups in place of the one-ohm coil. Do likewise with three, and then with four and five coils, and after they will all pass this duplicate testing, they will be pretty near right, and all in series may be connected up and a ten-ohm coil balanced against them, and so on up to the thousands.

The work must be very accurately done, and the measurements exactly taken, or when it comes to using ten units in series as a starter for the larger coils, the existing error will be multiplied in the same ratio, and make the box worthless.

The multiplying and dividing coils are to be built up in the same manner, only they are to be adjusted to 1, 9, 90 and 990 ohms. Made in this manner, they will, when plugged in, give series resistances of 1, 10, 100 and 1000 ohms. Fig. 66 shows the peculiar method of connecting this box, while Fig. 65 shows the method employed in many of the portable "testing sets." The ratios obtained by this method, are from $\frac{1}{1000}$ to 1000 against from $\frac{10}{1000}$ to $1000 \div 10 = \frac{1}{100}$ and 100. The ratio is therefore ten times as high, and ten times as low as in the old form, shown by Fig. 65.

Advantage can, and should, be taken of this matter when adjusting the resistances in R, for, by placing a plug between 1 and 3, a ratio of 9 may be obtained, and balanced against 9, 90 or 9000 ohms in R. It is by little kinks of this kind that the graduated coils are finally worked up to tally each other with very little error.

If a high grade galvanometer is at hand, use it by all means—the work will be much easier and more accurate; but if the pivot in the galvanometer here described, be kept sharp by occasional stoning—it is to be hardened as hard as fire and water will make it, too—the needle will "traverse" freely, even when loaded with two bits of mirror, and the pointer used in the completed instrument.

A very sensitive form of reflecting galvanometer may be made at a cost of $2 for material (mostly for wire) and the construction is very simple. The glass case consists of an ordinary lamp chimney, and the needle being astatic, made of two ordinary sewing needles fastened to a bit of thin copper which also carries the mirror. This galvanometer will probably be illustrated in these columns at no very distant day; meanwhile, blue prints from working drawings of the galvanometer, may be procured of the author at a nominal price.

Another point must receive particular attention—there must not be a single poor connection in the whole instrument. Everything must be soldered, and soldered well, too, without acid. Every wire connection ought to be tinned, then the wire tinned, and the two twisted firmly together, and well soldered with plenty of solder. The ends of the coils that are twisted up in adjusting the resistances should be most carefully soldered, and this will be found to be one of the most particular jobs in the whole business—particularly if the No. 36 wire be used for the 1 and 10 ohm coils. When soldering these coils, after they have been very carefully adjusted by twisting up, they will be found, upon measuring again after soldering to be too light, and some of the wire must be unwound again, after unsoldering the coil. This is because the resistance of the twisted connection is quite large, and being removed by soldering, leaves the coil too small. It is best to test the coils a trifle heavy, then solder, and give the final adjustment afterwards. Another soldering may then be given, to make fast the last portion of wire twisted up.

The wires, during the last soldering, should be pulled apart so as to stand at 180 degs. with each other. If left parallel, some of the solder will run up between the wires, short-circuiting them enough to destroy the value of the coil. Another important thing, and that is temperature. The testing should all be done with the coils all at the same temperature, and if a hot soldering copper be brought close to the instrument to solder a coil, there is no use to do any more testing until the coil has cooled off again to the normal degree at which it was originally tested. A good thermometer is very necessary, and all work on the instrument should be done, as far as possible, with the mercury between 60 and 70 degs. Most instruments of this kind are worked at 10 to 18 degs. C.

After the box is complete and fully tested—if not to your satisfaction, at least to the extent of your patience, it may receive final treatment by being dipped in melted paraffin wax, clear up to the hard rubber base-board. A square baking tin may be used for this purpose, but if the objection be made that too much spare paraffin is necessary to fill the dish, the coils may be carefully heated nearly hot enough to melt the wax, and liquid wax, barely hot enough to run, may be poured over the coils until *every portion* of them is coated with the wax.

WORKING MANY TELEPHONE STATIONS IN SERIES ON "CLUB" LINES.

BY D. H. FITCH.

In connection with the series of articles on "American Telephone Practice," it may interest readers to know of a system not heretofore described or in common use.

Service from this Exchange was begun before the expiration of carbon transmitter patents, hence with magneto transmitters, and for economy, on "club" or party lines.

It was soon found that with bells made upon the Watson plan, the impedance of the ringer magnets was so great, that magneto transmitters were impracticable for "club" line service. Carbon transmitters were yet out of reach; we must find some other remedy or fail. A remedy was sought and found in the construction of a ringer magnet which has practically no magnetic inpedance to speech currents.

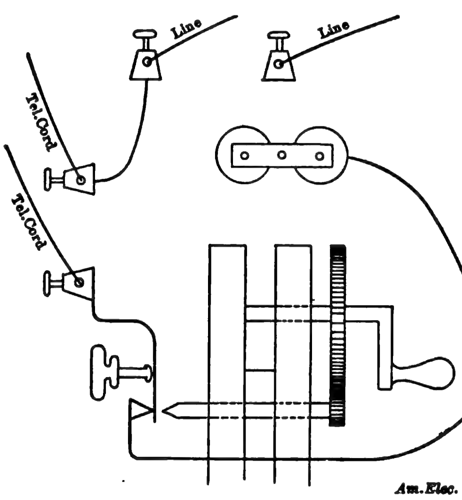


FIG. 1.

We wire our boxes with the ringer, generator and receiver in series, the ringer being permanently in the main line, the generator normally shunted in one of the common ways and the receiver circuit "short-circuited" when not in use. Figs. 1 and 2 illustrate the general arrangement of the box and the action of the hook lever. The upward movement of the lever closes the transmitter battery circuit, and the downward movement connects together the two usual cord binding posts, thus "short-circuiting" the receiver and transmitter circuit.

To simplify the interior wiring of the box, the main transmitter connection is made outside, by means of a short single cord or wire from one cord binding post on the box to one on the transmitter, and the tips of the usual telephone cord connected to the other binding post on the box and on the transmitter respectively, as is shown in Fig. 3.

A United States patent covering the construction of the non-impeding ringer magnet, has been issued to the writer. The

theory upon which I explain the non-impedance of the magnet has been disputed by some, but whether right or wrong, is immaterial; the fact remains that in practical service for two years in an exchange of nearly one hundred stations, mostly on party lines, it has done perfectly, that which it was designed to do—has demonstrated that, as to speech currents, it has practically no magnetic impedance.

Magneto transmitters are yet in use at thirty-five of our stations, the service being

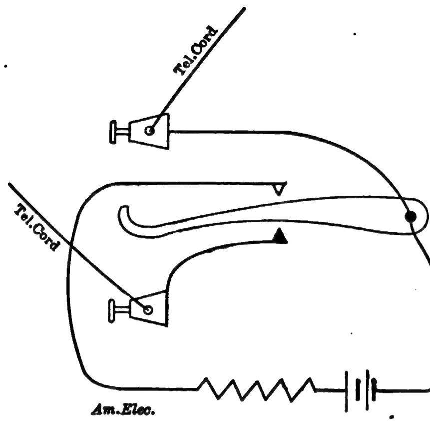


FIG. 2.

so satisfactory that subscribers have not desired to change to carbon. So far as transmission is concerned, our lines with the greatest number of stations do not work perceptibly different from those with one station only. There are at present 30 lines. We can connect our lines No. 2, seven stations, with line No. 6, eight stations, with a non-impeding extension bell on each line in the central office, in all, equal to *seventeen stations*, and transmit distinctly through the whole with the receiver at any of the

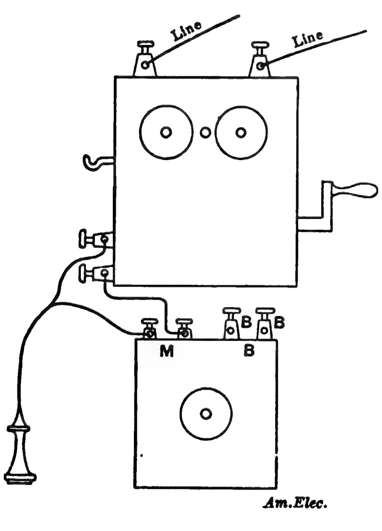


FIG. 3.

stations. In regular service, these lines are connected as often as any other. Two stations on one of the lines yet use magneto transmitters. All the lines are single grounded. We have no light or power currents to contend with.

The bells or generators require no high resistance winding, hence are cheaper than bridging bells, and I think the system every way preferable to that for working many stations on a line.

THE HOPKINSON METHOD OF DYNAMO TESTING AND ITS MODIFICATIONS.

In the previous article on testing dynamos a modification of the Hopkinson method was given, in which the stray power of two machines was determined. This is, strictly speaking, neither the Hopkinson method nor the stray power method, but a combination of them both, but from it an idea of what the Hopkinson method is, has probably been gained by the reader.

If the dynamo and motor are coupled together mechanically, the motor may be supplied with power and will drive the dynamo, and the dynamo in return will give out power, which may be used in driving the motor. If the machines had absolutely no losses, the power of the dynamo would be just sufficient to do this, but owing to the fact that there are losses, and sometimes very substantial ones, power must be supplied from outside to drive the system.

In the Hopkinson method this power is supplied mechanically and is carefully measured. The system is adjusted so that both machines run at full load, commercial conditions.

The mechanical power supplied to the system is measured and is equal to the losses of the two machines. Unfortunately, the losses of a machine running as a motor are somewhat smaller than the same machine running as a dynamo, for the reasons set forth in the previous article.

After the mechanical power supplied has been duly measured, the $C^2 R$ losses of the two machines must be substracted therefrom and the balance divided between the two machines in proportion to the armature voltages. From these results the total loss of each machine can be calculated, and the efficiency determined. Either series or shunt machines can be tested by this method, the field of the motor being weakened in the case of the shunt machine by the rheostat, and in the case of the series machine by the process of shunting.

The power delivered to such a system as this may be measured by any approved transmission device of measuring mechanical power. The calibrated motor, such as was described in a previous article, is very satisfactory, and any of the transmission dynamometers, such as the Webber bevel-gear dynamometer or the Emerson power scale may be used, but the precautions necessary in the use of such instruments must be observed. The tare loads must be taken and accounted for. The mechanical power will probably be measured in horse power and will have to be transformed into watts by multiplying by 746.

The calibrated motor arrangement is shown in Fig. 2. The two machines to be tested are connected together and belt-driven by the third, which supplies the power.

A very common arrangement found in installations is that of two similar machines, either belted or connected to the same engine, and this is a most admirable arrangement for testing for the efficiency of the dynamos. The current from one machine should be turned into the other machine, which will then run as a motor, and its engine will make up the difference in power, which difference can be measured by the indicator. Unfortunately, the results cannot absolutely represent the efficiency of the dynamos. If the engine is directly connected to its machines as shown in Fig. 2, the card taken during testing will measure not only the losses of the dynamos, but the friction losses of the engine also. By running the dynamos idly and taking a card, the result will represent the friction losses of the engine and of the dynamos also, and it will be seen that it is thereby impossible to exactly

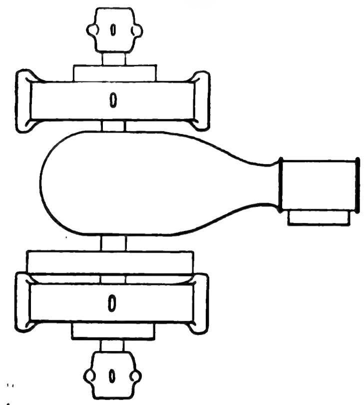


FIG. 1.—ENGINE CONVENIENTLY ARRANGED FOR HOPKINSON TEST.

separate the friction losses of the engine from the bulk loss measured in testing. The friction losses of the engine in such a case as this should be ascertained as follows: The dynamos should be unexcited, the brushes lifted, and the cap screws on the out board bearings loosened and then friction cards taken. The friction card will then represent, practically, the friction loss of the engine, plus the wind resistance losses of the dynamo; but the latter are so slight with most modern armatures that they will be completely masked by errors of the indicator. In estimating the power from the friction card, it may be well, where doubt arises and decimal figures are approximated, to give the engine the benefit of the doubt, and make the resulting power smaller instead of greater. This, however, is practically guess work, although it is guess work in the right direction.

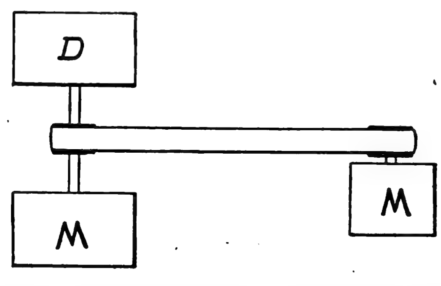


FIG. 2.—ARRANGEMENT OF MACHINES FOR TESTING BY HOPKINSON METHOD.

Where the machines are belted to the engine (see Fig. 3), the old trouble of belt loss will enter. A card taken when the machines are running each other at full load represents dynamo loss, belt loss and engine friction. A friction card with the dynamos unexcited represents engine friction, belt loss and dynamo friction. A friction card

with the belts off represents engine friction only. The losses that are desired to be measured exactly are the stray power and the C^2R losses of the dynamos, and it will be seen that this cannot be exactly obtained from any of the above cards, by a differential process or otherwise, for the belt friction is inseparably combined with the dynamo friction.

The nearest approximation we can get is, to lift the dynamo brushes slacken, the bearings, and run the combination at full speed, and take a card and assume that the difference between this card and the card of the engine with belts off, represents belt friction.

This will err by a fraction of per cent only, and in calculating results decimal ap-

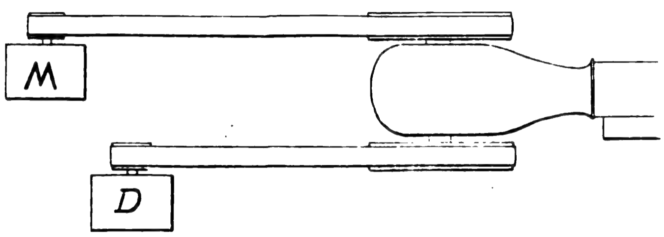


FIG. 3.—BELTED PLANT WHICH IS EASY TO TEST BY THE HOPKINSON METHOD.

proximations should be made in the right direction, as before stated.

An important point to remember in testing any system of dynamos where belts are employed, is the fact that belt slip means power lost in heating the belt and rims of the pulleys, and should not be charged against the dynamos, or the result would evidently not be fair.

To estimate this loss, take the speed of each of the pulleys on which the belt runs. The speed of the driven pulley will always be less than the ratio demanded of it by the driving pulley, and the difference in speed of the rims of the driving and of the driven pulley in feet per minute, will be the belt slip in feet per minute.

The difference in pounds of the belt tensions, multiplied by the slip thus found, and divided by 33,000 represents the horse power lost.

A convenient way of figuring this power is to assume that the ratio of the linear belt slip in feet per minute, to the speed of the rim of the driving pulley, is equal to power lost, divided by power supplied. For example, suppose that an engine is supplying 100-HP as measured by the indicator method, and that the speed of the rim of the fly wheel, as calculated from the speed of the shaft and the diameter of the wheel, is 5000 ft. per minute and the speed of the rim of the driven pulley of the dynamo, as calculated in a similar way is 4980 per minute, then the power lost is ascertained by the proportion $\frac{20}{5000} = \frac{x}{100} = .4$ HP, and should be subtracted from the input measured by the indicator.

Thus it can be very easily seen that belt slip might cause a serious error, and therefore it is very necessary, where the belts are inverted, to take the speeds as just described and make the proper calculations for the loss which such slip entails.

HANDY TOOLS IN A GENERATING STATION.

The workman about any installation which involves machinery, usually has a kit of tools suitable for work in hand, and which could not be duplicated anywhere because of their special character.

No where is this tendency to accumulate special tools more prevalent than in a power station. Most of these tools are easy to acquire and exceedingly convenient. They find thei greatest usefulness in such work as repairing the commutator, making temporary connections at the switch-board, boring or facing valve seats or cylinders, connecting the indicator to the engine, and scores of other purposes.

Undoubtedly one of the most useful tools in the power house is a rest for truing the commutator. In a well managed station, this should not be a necessary implement as a rule, but it frequently happens that carelessness has made its use unavoidable. Some manufacturers supply a rest for this purpose, but most of them do not. However, slide rests may be bought on the market that will answer every purpose. They are rather an expensive tool for the power-house employe to possess, costing between $25 and $30, but even if they should be used not more than once or twice a year, they will pay for themselves, and therefore the power station should be provided with at least one.

A slide rest should be selected, the longitudinal feed of which is fully two inches longer than the longest commutator bar in the station. Its application to the various dynamos about the station will undoubtedly

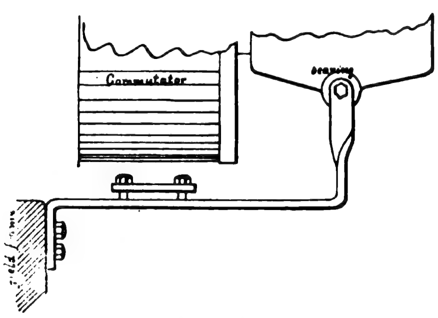


FIG. 1.—ARRANGEMENT OF SUPPORT FOR TOOL REST.

require different fixtures for each type of machine.

The chips that these tools are required to take off at a time are the very lightest that will suffice to remove the ruts and eccentricities, and if these be deep, several light chips will have to be taken. For this reason, the smallest size of tool and tool post on the rest will answer perfectly, and it is comparatively easy to obtain a rigid support when applying it to the machine.

Usually the field frame will have to be drilled, and a bar of iron bent to the required shape and bolted thereto, by ¾ in. cap bolts. 2 in. × ¾ in. iron will answer very well and can be easily bent to the required shape by any blacksmith.

It is sometimes advantageous to give the bar a twist, as shown in Fig. 1, and utilize one of the bearing-cap bolts to hold the end. As a general rule, the bar will be bent in some form of a right angle, but it is easy to see no rules of general application can be laid down. This arrangement will, of course, require a support of some kind which reaches down and finds a resting place somewhere on the base of the dynamo. Such a support may be conveniently made as shown

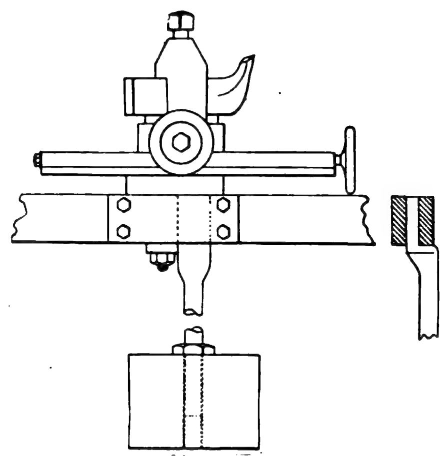
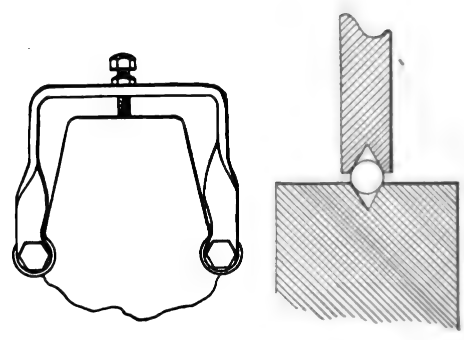


FIG. 2.—DETAILS OF CLAMP AND SUPPORT FOR TOOL CARRIAGE.

in Fig. 2. It consists of a 1¼ in. iron rod flattened to clamp to the 2 in. × ¾ in. iron by means of a flat clamp such as is shown.

This clamp is adapted to be screwed directly to the 2 in. × ¾ in. section. The rod itself is forged as shown in Fig. 3, so as to form a seat for the flat bar, and not depend upon the friction of the clamp to hold it in place.

The lower end of the rod should carry a



FIGS. 2 AND 3.—END PLAY DEVICE FOR ARMATURE SHAFT.

block of cast-iron not weighing less than 30 or 40 lbs., and should be adjustable by screwing up or down, as indicated in the above diagram.

A check-nut should be provided to tightly secure the rod to the block. This heavy block will hold the slide rest rigid, even if placed on the floor, provided the chip is light, but of course it is much better, although not always possible, to give it a seat on the dynamo frame. The rod should be clamped as nearly as may be to the point where the tool carriage also is secured. By making the flat clamp long enough, it will

be very easy to do this as shown in the sketch.

Every one who has worked on turning down the commutator knows that if there is end play in the armature, there is liable to be serious trouble, especially when working close by the lugs. There is a very small device which effectually prevents this end play while the armature is being turned. It is due to Mr. A. K. Bonta of the North Hudson County Railroad. It is best understood by referring to Fig. 2. The strap of iron, 1½ins.× ½in., is ample as bent to a U-shape, and the ends are given a one-quarter turn and bored, so as to go under the cap-screws on the out-board bearing; and here again no quantitative directions can be given, for bearings are different.

A ½ in. cap screw is fitted in a tapped hole, which cames exactly opposite the center of the shaft, and the end of the cap-screw is countersunk. A steel ball ⅜ in., more or less, as may be necessary for the bearing, is fitted into the pocket formed by these two opposite countersunk holes, as shown in section, Fig. 4.

The cap-screw is set up until the end play just disappears, and is locked in place by a check-nut. A few drops of oil on the ball should be applied, and the commutator may then be turned without fear of sudden end play that would cause the tool to gouge.

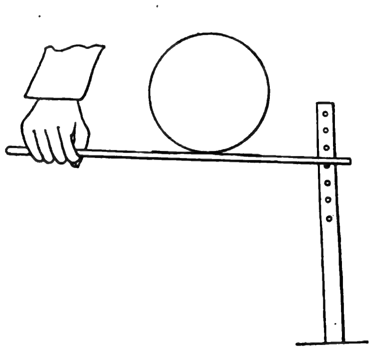


FIG. 5.—APPLICATION OF SAND-PAPERING DEVICE.

Commutators having been turned, should be polished with sand-paper, not emery cloth. A convenient tool for doing this is shown in Fig. 5. It consists of two boards, one of which is mortised to receive the other. The width should be a few inches less than the length of the armature bar to be polished. The other board is provided with a succession of holes of equal size, at equal intervals, and a pin is provided which will tightly fit in any of them. The application is very simple, and is shown in Fig. 5. The board is passed under the commutator, and the stick is fitted in its mortise, the pin being adjusted to support it at the proper height. The lower end of the stick finds a resting place on the floor.

By applying an upward pull on the handle, the sand-paper with which the board should be shod is tightly pressed against the commutator, and as it is a few inches narrow, it may be given a lateral motion so as not to wear ruts or scratches. Those who have attempted to polish the commutator by applying by main force sand-paper tacked on to a block will appreciate this idea as a great labor saver. Other handy tools will be described in a succeeding article.

ELECTRIC RAILWAY PRACTICE.

BY EUGENE C. PARHAM.

INSTALLING A TRIAL EQUIPMENT.

The writer feels impelled to apologize for calling attention in this article to many points which may seem commonplace to some and self-evident to others, but as the object is not to cater to specialists well versed in the art, it is hoped that if many points may seem trite or trivial considered *per se*, their consecutiveness may redeem the value of the time devoted to them by the reader.

We select the installation of a trial street-railway equipment because in this field competition is more evident, and failure of any link in the chain of success incubates germs of distrust in the patron and incurs the open disproval of a clamorous public.

We agree with the majority that all goods should leave the factory in good condition, and that a road man should have nothing to do but to place them; but in spite of every precaution, slips do occur and at most inopportune times, and a road man should exert himself to anticipate and prevent troubles liable to occur.

We will suppose that an equipment has been shipped and that a man has been sent to install it. Upon arriving on the field, his first move is to "size up" the working facilities and mentally adapt them to pending requirements, so that no delay may occur in the course of erection. As soon as the goods arrive they should be opened, checked off and inspected. An invoice facilitates checking off, but in any case the expert must exercise his knowledge of what constitutes an equipment to decide if anything is missing. Missing articles may possibly be omitted in the contract; whether or not this is the case, must be ascertained. Every article from the trolley wheel to the ground terminals must be inspected, and if defective, either repaired or sent to the shop to be replaced.

We will first consider the motors or gears as the most indispensable parts of an equipment. We inspect the gears to see: (1), that they are of the same bore as the axle; (2), that the two halves properly mate; (3), that, as far as the eye can judge, they are perfect—that is, have no broken or dented or nonuniform teeth; (4), that they are alike and adapted to mesh with the pinions provided.

Sometimes to meet special requirements special gearing is provided, and since the distance between car axle and armature-shaft center on any given motor is fixed, the number of gear and pinion teeth must have a certain relation or they will not mesh. Knowing the motor's standard gearing, it is easy to remember that any increase in gear teeth requires a similar decrease in pinion teeth and *vice versa*. If the car axle to be used requires the cutting of a key-way, notice the end on which it is to be cut, otherwise it will be necessary to remove the axle and turn it end for end so as to bring the key-way on the gear end of the motor. If a gib-key is used, the head goes towards the wheel and prevents the motor from forcing the gear over, thereby obviating the necessity of having a collar on the gear-end of the axle.

It will be noticed that motor-gear hubs are generally faced on one side and the faced side goes next to the motor. If the wrong side has been faced, the gear cannot be turned end for end, for that would bring the gib-seat on the wrong side; so the proper side must be faced. The car axle must be cleaned to receive the gear and must be cleaned and polished where the motor bearings go on.

In selecting a place for the gear, provide that neither the gear case nor motor shall in anyway interfere with brake rigging or other permanent fixtures. Should it be necessary to offset a brake rod or in anyway change or cut or bore any of the company's property, only do so with the approval of a responsible employe of the company. This is always a well-received courtesy, even when not a necessity.

The axle clean, and the key snugly fitted, the gear can be put on. The gear should require to be slightly forced, by laying it on a block of wood and tapping with a hammer. If gear and axle bore are exactly the same, a piece of thin paper laid smoothly on the axle will improve the fit. In case of a loose fit, emery cloth, rough side down, is sometimes used, and where the discrepancy is measurable, a collar of sheet-iron is interposed between gear and axle.

To put the gear on, the axle is turned key side up and the key-way half put on; then the axle is given a quarter turn and the other half put on, care being taken that the tongue in one half the gear falls into the groove in the other half. The eight bolts are put in and the four next the hub tightened up till the lock-washers refuse to give further; this should entirely close the seam along the hub. Upon tightening the four outer bolts the seam should nowhere admit the point of a thin knife-blade.

If it is impossible to satisfy this condition on the face of the gear, a $\frac{1}{64}$ in. gap is allowable, provided it extends uniformly across the gear face, otherwise the gear will have a high side, causing a wobbling motion and emitting a periodical grinding noise when the car runs.

The gear on the axle is ready to receive the motor, so the next step is to ascertain if the motor is in good shape. Notice the bearings to see that they are of the right bore and that the oil grooves are clean. By means of a lathe-dog on the pinion, turn the armature briskly to see if the armature bearings are free, and if the commutator has a high or low place in it, either of which latter faults cause the brushes to click when the faulty place passes under them. A high bar is easily detected by feeling and can be leveled with a file, but a "flat" requires that a light cut be taken off the commutator.

We now try the brushes to see how they move freely in the holder and that they have good tension, and further, be certain that no field-connecting lugs are left unprotected if left bare; carbon dust from the brushes and copper dust from the "scouring" of the commutator soon form a fairly good metal bridge to the field shell or motor frame, and upon the least provocation the current jumps over.

The next step is to test the motor insulation which, nine times out of ten, will be good, but the tenth time may reveal a grounded field, armature or brush holder.

This is because a motor gets hotter after a running test than during the test, due to the fact, that the fanning effect of the running armature cools all surfaces. It is a well known fact that a single ground on a circuit in no way affects its working; this is exemplified on a railway circuit where one pole is permanently grounded. It is very possible, then, in a testing room, where there may be no permanent ground, for a motor to pass through grounded if the tester fails to ground it and also omits the final insulation test with the voltmeter.

A "road" insulation test is usually conducted by means of a five-lamp bank, which should be in every road man's tool box; it is simply five lamp sockets mounted on a strip

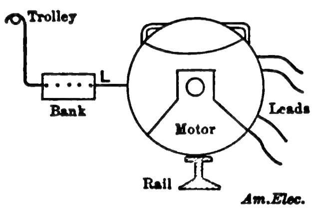


FIG. 1.—LAMP TEST.

of board and connected in series; to one end lamp is attached a long lead and to the other a short lead. To use the set, the sockets are filled with 110-volt lamps and the long lead is thrown over the trolley wire, as shown in Fig. 1. To test the motor insulation, set the motor on the rail and touch the short lead to the frame to see that the test circuit is intact. The motor leads are then lifted clear of the frame and successively touched with short lead, *L*. If any of them are grounded, the lamps light to full power. If they light a dull red it indicates moisture, which may cause trouble if the motors are installed in that condition. To bake them out, get a barrel and half fill it with water; get two pieces of wire to which attach two hunks of scrap iron and

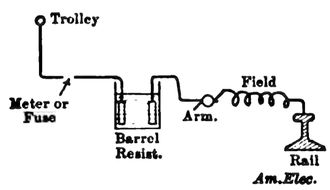


FIG. 2.—BAKING CIRCUIT.

connect up as shown in Fig. 2. If no ammeter is available for regulating the current, put in a fuse of half the motor's current capacity and push the hunks of iron together till the fuse begins to blacken. Let the motor bake till the lamps no longer light when the bake circuit is open and the lamp circuit closed. To prevent the armatures turning, reverse half the motor field coils.

Giving the motor a final inspection to see if there are any broken lugs, missing screws, bolts, nuts, washers or cotter pins, and pouring a little oil into the armature bearings, it is ready to swing into the truck. The next step is to adapt the suspension provided or to rig one to suit the truck and motors. This done, the axle and motor linings are greased with a No. 2 grease and all grease cups filled. The motors are now swung into place, all bolts secured, a collar put on the axle on the commutator end, and if the motor sits properly, the gear case put on. The suspension side of the motor should stand an inch or so higher than the axle side to allow for the dip which one motor makes at starting.

The truck is now jacked up and the motors blocked, so that when the truck jacks are released the wheels clear the floor. The motors are connected in series with each other and with a resistance, as shown in Fig. 3, and given a spin to see if the commutator runs smoothly and if the gear grinds, clicks, or rubs the gear case. If the gear emits a periodical buzzing, it indicates wobbling, due to bad setting; one click per gear-revolution indicates an open gear, a loose key or a big or little or dented tooth; if the click occurs once per pinion-revolution the trouble is there. A big tooth shows wear and can be fixed with a file; a small tooth makes a gear useless. If the gear rubs the gear case, the latter must be hammered to fit, if brass or malleable iron, and planed if cast-iron. If the gears run well, their cases are charged with a gallon of gear grease and permanently closed.

Before finally disposing of the truck, see that its journals are packed and that its wheels are of the same size. The next step is to get the car body ready; this on a new car consists in placing the trolley pole and base, the roof wiring, lighting circuit, hood switches, controllers, lightning arrester, fuse box, motor cable and heating circuit. On top the car is generally found a board called the trolley bridge, running lengthwise of the car; on this board the base is bolted. The precautions to observe in placing a trolley are to see that all moving parts are well oiled, that the wheel turns freely, that the harp sets straight and that the spring tension is strong enough—15 to 25 lbs., according to service. The hood switches, controllers, wiring, etc., will be taken up in another article.

ROTARY VALVES.

This heading covers that multitudinous type commonly known as "Corliss" valves, perhaps the most widely distributed of any method of steam distribution. Strictly speaking, these valves are semi-rotary, as they do not make a complete revolution. They have also been called "Vibrating" or "Oscillating" valves, but the term "Rotary" serves to distinguish them sufficiently for our purpose, from the kinds discussed under the title of "Slide" and "Piston" valves.

The general arrangement of this type of valve is shown by Fig. 1, although the varieties are many, as the succeeding engravings show. The steam valves are shown in section at the top, the exhaust valves at the bottom of the engraving. It will be noted that the distance from steam chest to cylinder is very short, and the passage straight and direct. The things required of these valves may be briefly stated as follows:

(*a*) The steam valves should open quickly so as to secure full boiler pressure in the cylinder from admission to point of cut off. (*b*) The valve should close instantly as soon as the cylinder has received steam enough to do the work required on that particular stroke of the piston. (*c*) The exhaust valves must open fully so as to give full port area to the exhaust steam, and still close in time for the required amount of compression.

The valves being long, their length extending across the diameter of the cylinder, the port opening can be quite narrow, and still open a large cross-section area with a small movement of the valve. The gear is so arranged that the valve opens near the

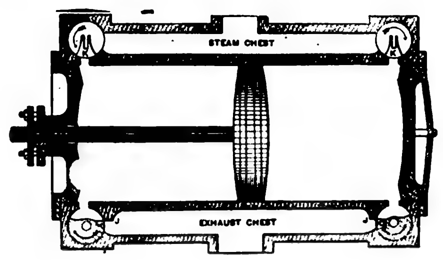


FIG. 1.—GENERAL ARRANGEMENT OF CORLISS VALVES.

middle of the eccentric travel, thus taking advantage of the rapid motion at that point. This secures approximately, the requirement (*a*).

By releasing the valve, and closing it by a vacuum pull, requirement as to quick closing is secured, but this function belongs to the dash-pot, and the valve can in no way take credit for that work, and the release of the valves by the governor, takes care of (*b*).

The full opening of the exhaust valves is made positive by permanently connecting them to the eccentric by means of the wrist plate, and the quick opening and closing of these valves is made sure of by giving the valves some over-travel, so they may be moving at a good rate of speed when they are open and closed. This attends to requirement (*c*).

Although there is a great difference in the construction of Corliss valves, the following table gives a rough and ready way of approxi-

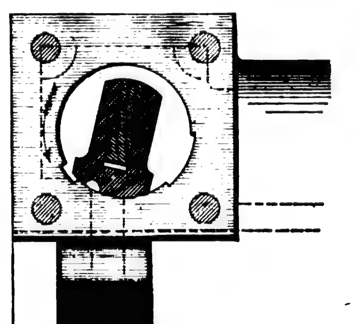


FIG. 2.—AVOIDING "SHOULDER TRAVEL."

mating the lap and opening of valves for different sizes of engines, viz:

Size of Engine.	Lap of Steam Valve.	Exhaust Valve Open.
12 ins.	1/4 in.	1/32 in.
14 "	5/16 "	1/32 "
16 "	5/16 "	1/32 "
18 "	3/8 "	1/16 "
20 "	3/8 "	1/16 "
22 "	3/8 "	1/16 "
24 "	7/16 "	3/32 "
26 "	7/16 "	3/32 "
28 "	7/16 "	3/32 "
30 "	1/2 "	1/8 "
32 "	1/2 "	1/8 "
34 "	1/2 "	1/8 "
36 "	1/2 "	1/8 "
38 "	9/16 "	3/16 "
40 "	9/16 "	3/16 "
42 "	9/16 "	3/16 "

It was early found that the semi-rotary

valve was subject to the same troubles regarding wear, that interfered with slide valves, and provision was early made to prevent trouble in this direction by arranging the parts to wipe over each other instead of forming shoulders where the reverse of motion and change of travel occurred.

Some Corliss valves require springs to keep them to their seats; others do not. Some have very direct straight passages for the steam, while others, like those in Fig. 3,

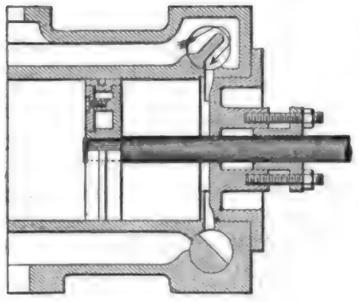


FIG. 3.—CIRCUITOUS-STEAM TRAVEL.

force the steam to travel around the "backbone" of the valve, which action not only makes the steam travel longer, but also forces it to make a very sharp angle of 180 degs., which cannot but reduce the pressure to a certain extent. This is avoided in the form illustrated by Fig. 4, where the valve is cored out, and a direct passage made for the steam. Either of these valves, if given motion in the opposite direction, would offer a more direct passage to the cylinder, but there are very good reasons why it is desirable to swing the valves in the direction they are made to take. One of these reasons is that the valve seat wears badly with the other arrangement.

No springs are required with the form of valve shown in this engraving, the method of construction rendering them unnecessary. A very quick opening, direct passage form of valve is shown by Fig. 5. This is called the "Double Ported Valve." It increases the clearance space a trifle, but has the ad-

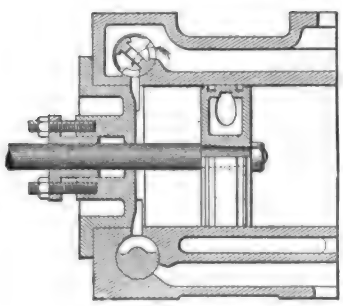


FIG. 4.—DIRECT-STEAM PASSAGES.

vantage of giving a quick, sharp opening and closure.

Contrasted with the short wearing surfaces of the valves shown in Fig. 5, is the wide surface of the T-head on the valve in Fig. 7. Note also that the closing of the exhaust valve makes all the space contained in the valve chamber, and not filled by the valve itself, a part of the clearance space. Note also that the exhaust passage is cast close to the cylinder, with only a thin wall of cast iron between. Here, the loss of heat by the cooling effect of the exhaust steam must be considerable.

In Fig. 7, it will be seen that the exhaust valves seat directly beneath their centers, making the weight of the valve available for keeping it closed. The space through the valve is also filled, with the exception of

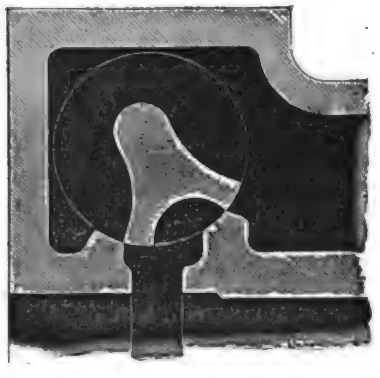


FIG. 5.—DOUBLE-PORTED VALVE.

a passage as large as the port, so that the clearance space is made as small as possible. In this illustration, the steam valve is shown to move with the steam, instead of against it, as in Figs. 3, 4 and 5. This brings the steam directly across the valve seat, to which objection was made above, but the cutting action of the steam is somewhat modified by the inclination given to the port by pitching it several degrees nearer parallel with the bore of the cylinder. With the opening directly in the bottom of the valve chambers

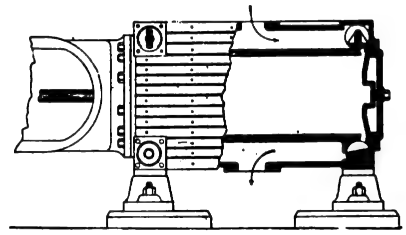


FIG. 6.—"T-HEAD" STEAM VALVE.

there is no opportunity for water to collect, and it has a free passage straight through the cylinder, should any happen to come along with the steam.

In the next engraving, Fig. 8, a slide valve is shown so arranged as to be actuated by Corliss valve gear. The action and effect is about the same as with the rotary valve, but the claim is made for it, that as the valve can be scraped to a fit at any time, it can be kept tighter than a rotary valve and also possesses a much longer life. The claim is also advanced that as the valve closes with the current of steam, the action assists the action of the dash-pots, thereby effecting a sharper cut-off than can possibly

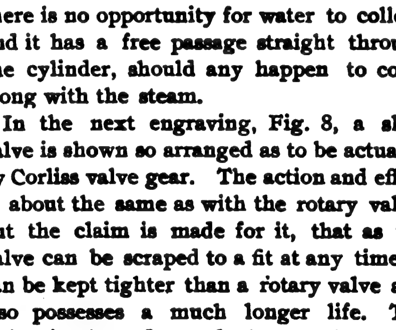


FIG. 7.—CORED-EXHAUST VALVES.

be claimed with any rotary valve. From this and the preceding paragraphs, it will be seen that there are claims for, as well as against, the practice of opening a valve in either direction. I will not attempt to decide the question of which is the best.

A feature in regard to the close regulation of Corliss engines may be mentioned here, although it really has nothing to do with the valves. It is this, the driving of the governor at a speed several times that of the engine shaft. When one revolution of the shaft will cause four or five revolutions of the fly-balls, the action of the governor can be much quicker, than where the balls re-

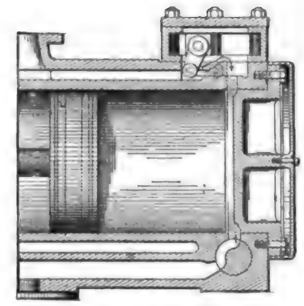


FIG. 8.—CORLISS SLIDE VALVE.

volve slower. It is claimed that the governor running from two to three times as fast as the engine shaft, causes the governor to act from four to five times as quickly. In the next issue the subject of Corliss valves will be concluded.

LESSONS IN PRACTICAL ELECTRICITY

THE BIPOLAR DIAGRAM.

In several of the preceding lessons the clock or bipolar diagram was referred to in general terms, and in this installment its application to the solution of alternating-current problems will be taken up. The deductions from it will be of great importance, as among them is the method of solving alternating-current problems which corresponds to the arithmetical method employed with the simple form of Ohm's law used with direct currents. Following the plan of these Lessons, the subject will be taken up from first principles.

Suppose the upper part of Fig. 1 represents the armature and pole pieces of a bipolar dynamo, the field in the air gop of which is everywhere uniform. The circumference of the armature is supposed to be divided into forty parts, but reference will be only made to ten of these—those in the upper right hand quadrant. The E. M. F. generated in a conductor moving in a field cutting lines of force is measured, in rational units, by the product of the length of the conductor and the number of lines cut per second. Referring now to the diagram, it will be seen that while the conductor passes from A to B it cuts very few lines, its direction of motion being nearly parallel to the direction of the lines of force. It will also be seen that as it advances through section by section, the number of lines cut in each succeeding section increases, and finally becomes a maximum in moving from I to J, since its motion at that locality is almost perpendicular to the lines of force.

If the reader will construct on a very

large scale such a diagram, drawing in it numerous lines of force, he may count those which will be cut while the conductor is moving through each section. Should he do so and lay off vertically from a horizontal line the values thus found, he will

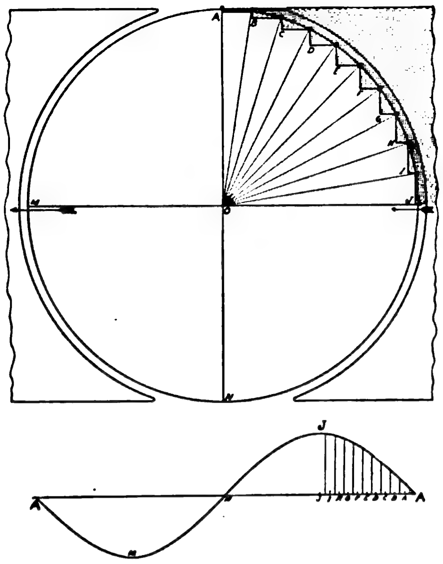


FIG. 1.—GENERATION OF ALTERNATING CURRENT E. M. F.

get such a curve as that shown in the lower part of Fig. 1. This curve happens to be a true sine curve, and we thus see how the sine curve enters into the consideration of alternating currents. A single conductor on the armature of Fig. 1 during each revolution will generate E. M. Fs. of such values that, if plotted as shown, they give the sine curve; and multipolar alternators are so designed that a conductor in moving from under the center of one pole, across the adjacent one and to the center of a third, has generated in it a complete sinusoidal cycle of E. M. F.

It would not be necessary, however, for the reader to make such a construction as that referred to, as he can find the values he desires in a much simpler manner. Referring to Fig. 2, which corresponds to the upper part of Fig. 1, if the line *a o* represents the maximum E. M. F. (which, of course, occurs in the middle of a field) then the line, *b m*, will represent the E. M. F. when the conductor is at *b*, the line, *c n*, the E. M. F. when the conductor is at *n*, and the line, *f r*, when the conductor is at *f*, there being no E. M. F. when the conductor is at *g*, as it is cutting no lines at that point. On the right of Fig. 2, is a curve laid down by dividing the horizontal line into equal parts,

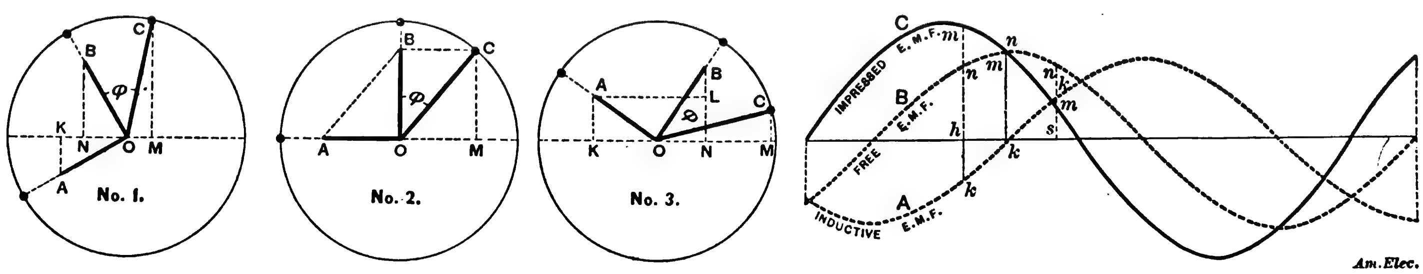


FIG. 4.—CURVES OF INDUCTIVE, FREE AND ALTERNATING E. M. F.

o m, *m n*, etc., and erecting the perpendiculars, *a o*, *b m*, etc., corresponding to the lines similarly lettered to the left.

Referring now to Fig. 4, the right of which was used in Lessons for last month, we see how conductors on the circle representing the circumference of a bipolar dynamo, will generate the several sine curves shown. The arrangement of these several conductors are shown in Fig. 3, *A*, *B* and *C* corresponding to the points on No. 2 of Fig 4. The free E. M. F. would be generated by the conductor, *B B'*, the inductive E. M. F. by the conductor, *A A'*, and the impressed E. M. F. by the conductor, *C C'*. As the lengths of these three conductors on the surface of the armature are different, therefore in the revolution of the armature in a uniform bipolar field E. M. Fs. will be generated proportional to these lengths. The conductor, *A*, is at right angles to the conductor, *B*, for the reason, as explained before, that the inductive E. M. F. is greatest when the current flowing (which is in phase with the free E. M. F.) is least, and has a minimum value when the value of the current is greatest—which follows from the fact that when the value of current is a maximum the change in a given time of the number of its lines of force is least, and is greatest

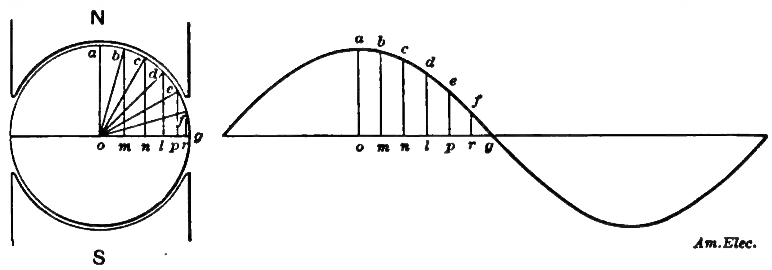


FIG. 2.—CONSTRUCTION OF SINE CURVE.

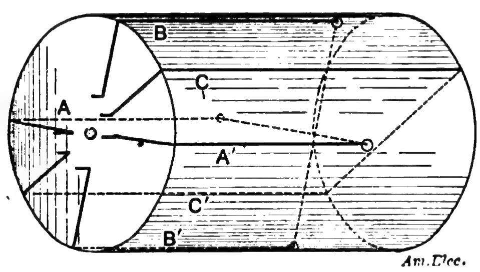


FIG. 3.—BIPOLAR DIAGRAM—ARMATURE.

when the current is passing through its zero value, as may be readily seen by inspection of one of the accompanying curves.

In Fig. 4, three different positions of the armature are shown. No. 1 corresponds to the E. M. F. on the vertical line at *h* in the figure to the right; that is, the E. M. F., *h k*, due the conductor *A*, is equal to *K A*; *h n* due the conductor *B*, is equal to *B N*; and *h m* due the conductor *C*, is equal to *CM*. The middle dotted line to the right of the figure corresponds to position No. 2 and the vertical line erected at *S*, corresponds to position No. 3; the reader will see that in each case the lengths, such as *s m*, are always equal to the corresponding lines, such as *CM*, of the bipolar diagram. In No. 2, the length corresponding to *A*, is zero, which means that the curve, *A*, is at zero or *k*; the line, *CM*, represents the E. M. F. of both conductors, *B* and *C*, which means that at this position of the armature the two corresponding curves cross, as shown at *m*, of the middle vertical in the figure to the right.

We have previously shown how the curves to the right may be directly laid down from the data of a given case. In practice this is never done, the bipolar diagram being used alone in calculations. In fact, only part of this diagram is used, as will be shown later. In order, however to make calculations intelligently, the principles involved should be understood, and for that reason the somewhat extended explanations of these Lessons have been given. Ordinarily the student is introduced for this purpose to the theory of the parallelogram of forces, or to that of vector analysis, but usually it is best to learn from first principles and afterwards connect the processes developed with general theories.

Referring again to Fig. 4, since the current (which is in phase with the free E. M. F. or has its zero value simultaneously) is increasing in value, and therefore sets up a counter inductive E. M. F., the impressed E. M. F., *m h*, must be equal to the sum of the free E. M. F., *n h*, and the inductive or back E. M. F. *h k*, thus set up; that is, in No. 1, *CM*, is equal to $KA + BN$. Similarly, the impressed E. M. F., *m s*, must be equal to the difference of the free E. M. F., *n s*, and the inductive E. M. F., *m s*, for the reason that, as the current flowing (which is in phase with the free E. M. F.) is decreasing, its lines cutting out of the inductive circuit generates an E. M. F., *m s*, in the same direction as the free E. M. F., and therefore supplying part of it; that is, $CM = BN - AK = BL$.

In other words, *CM* is always the sum or difference of *A K* and *B N*. No. 2 of Fig. 4 gives the construction in which this relation always obtains. The known points *A* and *B* are connected by the line *B A*; another line, *O C*, is drawn parallel to this;

and the line BC parallel to AO; the intersection of these gives the point C, which fixes the value of the unknown E. M. F. Moreover, BOC is the angle between the free current and impressed E. M. F. of the corresponding conductors on the bipolar diagram. As the free E. M. F. is in phase with the current, this is also the angle between the current and impressed E. M. F., or the angle of lag.

This diagram is known as the parallelogram of forces, but for present purposes may be accepted as merely a graphical construction applying to the particular case in hand.

In practice even the above construction is simplified. As shown in Fig. 5, it is only necessary to draw the full lines AO and BO, in which case the angle of lag is AOB, since that angle is equal to the actual angle, BOC.

Finally, to illustrate the above, we will take the case of a choke coil having a resistance (R) of 2.1 ohms and a self-inductance (L) of 10 millihenrys (.01 henry), and find the E. M. F. necessary to apply at the terminals in order that an alternating current of 1 ampere may flow through the coil, the frequency (n) being 133.

The free E. M. F., (CR), is $1 \times 2.1 = 2.1$ volts. The inductive E. M. F. is $2 \pi n L C = 2 \times 3.1416 \times 133 \times .01 \times 1 = 8.35$ volts. In Fig. 4 lay down BO to represent 2.1 volts of free E. M. F. and OA 8.35 volts of inductive E. M. F.; then the length of AB will represent the impressed E. M. F. This length may be found by solving the right angled triangle BOA instead of by mea-

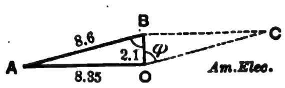


FIG. 5.—TRIANGLE OF INDUCTIVE, FREE AND IMPRESSED E. M. F.

surement. The square of the hypothenuse, AB is $(8.35)^2 - (2.1)^2 = 835.66$, and the square root of this is 8·6, which is the value of the impressed E. M. F., AB. If an E. M. F. of 100 volts is applied to the coil, a current of $100 \div 8.6 = 11.6$ amperes will flow.

The tangent of the angle, AOB, is the quotient of the base by the perpendicular of the triangle, or $AO \div BO = 8.35 \div 2.1 = 3.93$. Referring to a table of natural tangents, we find this to correspond to an angle of 76 degs. The utility of this angle will be found later, when dealing with the calculations of power.

Continuous-current calculations involve only arithmetical processes. As we have seen, alternating-current solutions, on the other hand, are trigonometrical. In all ordinary cases, however, the right-angled triangle alone is involved, which requires no knowledge of trigonometry for its solution, the square of one side being merely the sum or difference of the squares of the other two sides. Also, as shown above, no trigonometrical knowledge is required in the case of a right-angled triangle to find the angle of lag, it being merely necessary to divide the value of the base by the value of the perpendicular, and pick out from a table of tangents (given in mechanical and other handbooks) the angle which corresponds to the value thus found.

SOME ELECTRICAL SPORT—IV.

BY JAMES F. HOBART, M. E.

When rudely awakened at midnight
By feline yowls let loose,
Just set magneto a whirling
And give the cats some juice!

It is interesting—for those who like it—to listen to the "continuous performance" that takes place in the back yards and on the fences thereof, especially during the summer months. After bearing with this sort of thing as long as possible, and using up all the available ammunition in the shape of small portable articles and a portion of the vocabulary which is oftener spoken than written, I determined to abate the nuisance, even if dynamite had to be used.

A magneto was procured—a good strong one—of the variety used for ringing up signals where the magneto time detector clocks are used. It would ring through 10,000 ohms well enough. The instrument was set up in a convenient chamber, and wires run to the back yard, passing along the board fence. Several wires were connected so that when hanging down, they would reach to the ground with a couple of feet to spare. These wires were No. 34 iron. They were very strong, and not insulated. Several pieces of tough meat were procured and a wire well wound around each piece. Then the bits of meat were laid on top of the fence, and developments awaited.

Soon a cat would find one of the pieces, and in tasting it, would knock the meat off the fence. The feline was sure to follow, and once on the ground, lost no time in bolting the meat with the wire attached. The instant the morsel was down, and before the cat had time to investigate the wire, the magneto was set agoing, and—the fun commenced. The other terminal of the magneto had been grounded on the water pipes, and the cat standing on the earth, had full benefit of the sharp alternating current. It was sport—for the beholder at least. For the cat? Well, it was gymnastic exercise of the highest order, with ground and lofty tumbling thrown plentifully in, and it invariably continued until the wire broke, which usually required five or six minutes time.

The same cat never came for two doses. One that had "been there" would walk the fence next day, as if electricity was unknown, but as soon as the animal encountered one of the bits of meat, he would take one sniff, give a terrified glance around, and "scatter" to the next yard so suddenly that the beholder was convulsed with laughter.

After the meat business had become an old story to all the cats in the neighborhood, some narrow strips of very thin brass were procured. It can be obtained as thin as paper, and of any width, in continuous rolls. The kind I used was ¼ in. wide, and so thin that it could be doubled up in the hand—probably No. 30 or No. 32. Two lengths of this were nailed to the top of the fence everywhere a cat could walk, and connected by wire to the magneto. It was almost impossible for a cat to walk on top of the fence, and avoid stepping on both pieces of the brass.

Eventually, I divided the back fence into several sections, and ran wires from each section to a little switch-board, where push buttons enabled me to make contact with either section at will. This varied the entertainment greatly, for I found that when a heavy current was sent underneath a cat, the animal would simply roll right off the fence, much like the "rolling off a log," that we hear so much about, but when tickled with a light current, the cat would leap into the air and come down in its tracks again, and look around to see what was up.

With the push buttons, and two cats on as many sections of the fence, I could turn the magneto gently, and put up the most ludicrous performance imaginable, making the cats take turns, and winding up with a tremendous rush of current which tumbled them both off the fence at once. The neighbors appreciated it, and I did, too. As for the cats, they didn't serenade when I didn't want them to.

Letters on Practical Subjects

Municipal Ownership.

To the Editor of American Electrician:

As a contribution to the question of municipal control of private enterprises, Mayor Warwick's reasons for his approval of the lease of the gas works of Philadelphia, constitutes a valuable addition to the already abundant evidence against the acquisition under existing conditions, of such enterprises by the government.

After giving his reasons for his action in this case in particular, the Mayor continues by asserting that, "It is a grave question in my mind whether or not any municipality should operate any manufacturing industry. The constant succession of administrations every four years, the consequent changes in the heads of the departments, the inability to continue by reason of these changes a settled definite policy, looking to one end, must prove to every thinking man that these conditions greatly interfere with the successful operation of any business enterprise. There is no private business that could prosper under such a system."

WALTER H. SONNEBERG.
Philadelphia, Pa.

Taking the Speed of Motors.

To the Editor of American Electrician:

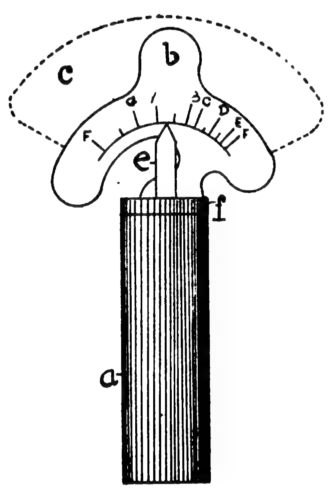
In testing motors and dynamos, it is necessary during the run to take the speed of rotation a great many times. Where there are a large number of machines undergoing test at the same time, the office of the "Revolution Clerk" is no sinecure. Aside from the amount of time consumed in taking the number of revolutions, there is always danger of physical error which will vitiate the results obtained, to a degree that will make them valueless. There is, however, a method of ascertaining, at any in-

stant, the number of revolutions per minute a generator or motor is making without counting or timing. This is done by taking the musical tone made by the commutator. Any commutator can be thus speeded provided the exact tone can be ascertained, and the number of segments in the commutator are known. The principle of the thing is as follows:

The brushes passing the commutator segments, cause vibrations of the air surrounding them, and upon the rapidity of these vibrations, depends the pitch of the musical tone made by the commutator. In any book on natural philosophy can be found the tone produced by any given number of vibrations per second. A portion of such a table is as follows:

$F = 348.4$	Octave	$F = 696.8$
$G = 392.4$	"	$G = 784.8$
$A = 431.2$	"	$A = 862.4$
$B = 470$	"	$B = 940$
$C = 510$	"	$C = 1020$
$D = 585$	"	$D = 1170$
$E = 658.4$	"	$E = 1308.8$
$F = 696.8$	"	$F = 1393.6$

It will be seen that the vibrations per second exactly double in going an octave higher, consequently they divide by two, in going an octave lower. With a "pitch



ACOUSTIC SPEED INDICATOR.

pipe," as shown by Fig. 1, the hum of the commutator can be exactly caught, or an octave of it can be reached by the pitch pipe. In this instrument, the barrel *a*, is put in the mouth. Inside of the barrel, is a common brass reed. Moving the segment *b*, causes the plunger *e*, to move in and out, and covers up more or less of the reed so as to make it give a high or low note. By moving the segment until the tone of the pitch pipe is the same, or an octave of that given off by the commutator, the pitch of the hum may be read off on the segment, which covers from *F*, to *F*, one octave. Supposing we have a motor with fifty-seven segments, and the tone proves to be *B*, an octave higher than the *B* on the pipe.

The tone carries 940 vibrations per second or 56,400 per minute. Divide by the number of segments, 57, and the speed is found to be 988 r. p. m. A piece of brass may be put on the instrument, as shown by the dotted lines at *c*, and on this brass, the speeds may be worked out and laid down direct for any given commutator. Or the vibrations per minute can be laid down there and the speed found by dividing by the number of commutator segments. It is very essential that the brushes stand exactly opposite each other so that they will both leave the segments at the same instant; otherwise there will be *confusion in taking* the pitch of their hum. GEORGE EASTLAKE.

St. Louis, Mo.

Blasting Fuses.

To the Editor of American Electrician:

Referring to the letter of Mr. Francis, p. 453 of November issue, fuses as used in this country for blasting purposes *take time* to get hot enough to explode the cartridge. So it will be seen that it is of no use to switch the current on only at the highest velocity of the armature. If Mr. Francis will take some of the ordinary blasting fuses he might experiment with ordinary batteries, to see how much current they need.

As to the theory of "building up" the current, this applies to some blasting fuses of a type I have not yet seen in this country, but which are used very much in Europe These fuses are designed for a spark jumping across a small gap, which gap is filled with a mixture of antimony-sulphide and potassium chlorate. In many instances an induction coil is used instead of a magneto, especially if there are a number of mines, when the fuses are all connected in series. In experimenting, I would advise that the fuses be covered with sand, so that nobody will get hurt by flying particles.

Brooklyn, N. Y.

HENRY P. J. VAN DETH.

Good and Bad Commutator Segments.

To the Editor of American Electrician:

A short time since, I had a little experience with commutator segments, or rather, the other fellow had the experience, and I saw it all and "took in" the information to be derived therefrom. A certain small generator which had for some time run in the most exemplary manner, suddenly began to give trouble by having a very rough commutator. The bars would become rough, and no matter how smoothly they were turned off or smoothed down with sandpaper, a very short run would rough them up again. It seemed as if some of the bars would raise up above the others.

The armature was finally sent to a repair shop, and I followed it. When the commutator was taken down, the following condition of things was found: Originally, the segments or bars, were of the shape indicated in Fig. 1, being held at either end by a conical or V-shaped projection, in the usual manner. But these bars were worn to the shape shown by Fig. 2. In fact, they were cut almost in two in the middle, and there was a very perceptible bend in the remaining metal, where the bar had sprung under the pressure of the cones and the tightening screws.

Here was the cause of the trouble with the commutator, and it is a matter which has caused a good deal of trouble in other machines made as this one is. Beyond all doubt, the commutator was run too long, and should have been renewed before, but there was still more than enough metal in the remainder of the bar to carry all the current without undue heating; therefore, if the cone pressure had not caused trouble, the commutator could have run several months longer with renewal.

Fig. 3 shows this matter. If the point of the cones were lowered, as shown in this drawing, the line of pressure would also be lowered, as seen by comparing the horizontal dotted lines in Figs. 2 and 3; these lines representing the direction of thrust, or

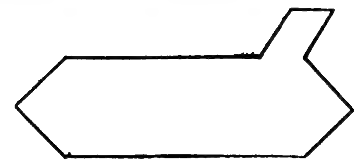


FIG. 1.—ORDINARY COMMUTATOR BAR, NEW.

rather, of compression, which holds the bars in place. In Fig. 2 there is a tendency to force the remaining metal downwards, and this tendency is acted against by the centrifugal force of the bars. The result is, that some of the segments work loose and crowd down toward the shaft, while occasionally one of them, which perhaps is not held as tightly at the ends as the others, springs outwards, and becomes a high bar among several in correct position, while adjacent there is a bar or two which has been crowded in, and remains low.

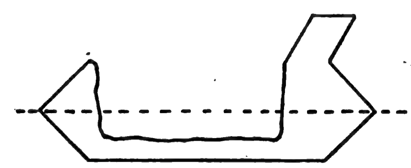


FIG. 2.—ORDINARY COMMUTATOR BAR, WORN.

It seems as if it would be well to put a bearing in the center of long commutators, especially where they could be expected to run until the bars were worn very thin. The bearing could be in the form of a ring slipped on the shaft, and covered with the necessary insulation to prevent short-circuiting the commutator. A portion of the inner edge of each bar could be milled off or otherwise "spotted," to receive the insulated bearing ring, which in turn, could be slipped—with its insulation on—into the commutator when it was built up. The ring would bake to the

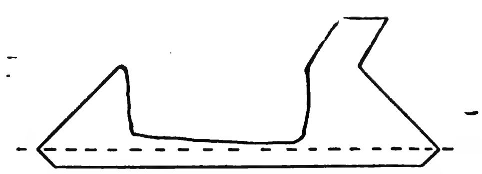


FIG. 3.—WORN SEGMENT WITH CONES LOWERED.

segments as the shellac evaporated, and a very solid form of commutator would be the result, which would be free from about all possible vibration when worn considerably.

If the closed ring was found to give trouble when assembling the commutator, a ring split in two or more pieces could be used, being slipped in after the commutator was

set up and ready for baking. In this case, the insulation on the ring could be varied to fill the cavity between the ring and the inside of the commutator.

.Pittsburgh, Pa. S. L. CORSON.

ELECTRICAL CATECHISM

NOTE.—In the catechism for November, Fig. 2 was incorrect. The curve marked "Current" should have been marked "E. M. F. of self-induction" and *vice versa*.

173. How can the angle of lag be determined experimentally?

The angle of lag can be calculated if the amperes, volts and watts are known; for the watts equal the product of amperes by volts by cosine of the angle of lag. (The mathematical proof of this is somewhat complicated and will not be given here). Dividing the watts by the product of amperes by volts gives the cosine of the angle of lag, from which the angle itself can be found by referring to a table of sines and cosines. For example, an A. C. arc lamp is advertised to take 400 watts at 104 volts and 6 amperes. Dividing 400 by the product of 104 by 6, or by 624, gives 0.641 as the cosine of the angle of lag. Referring to a table, we find that 0.641 is the cosine of 50° 8′. Fig. 1 shows the relation of current and voltage for this case, the current being plotted to a larger scale than the voltage in order to make the two more nearly the same size. In the upper part of the figure, the two curves show how the voltage and current each rise and fall following "sine curves," the maximum and zero values of the current being 50° 8′ behind the corresponding values of the E. M. F. The lower part of the figure shows the same thing in a different way, showing directly the angle between corresponding values.

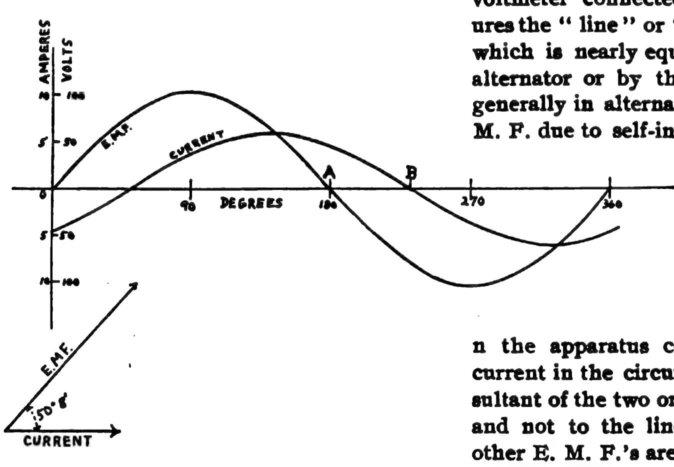


FIG. 1.—LAGGING CURRENT.

174. When an alternating current lags behind the E. M. F. is there not a considerable current at times when the E. M. F. is zero?

Yes. The current may be quite large when the E. M. F. on the line is zero. This does not mean that one could get current from a line that showed no E. M. F. when tested with a suitable voltmeter, for no current would flow under such conditions. It is true, however, when an alternating E. M. F. causes current to flow, that the E. M. F. varies from zero to maximum values many times each second, and that the current may be quite large at an instant when the E. M. F. is zero.

175. Does not Ohm's law hold true for alternating currents?

Yes, it does when properly interpreted and applied. It holds true for every instant in its simple form, the current equalling E. M. F. divided by resistance. Also it holds for values as averaged, if properly used.

176. Then how can there be current flowing at an instant when the E. M. F. is zero?

The current at any instant is governed not alone by the E. M. F. on the line, but by the resultant of all the E. M. F.'s acting. A voltmeter connected across the line measures the "line" or "impressed" E. M. F., which is nearly equal to that given by the alternator or by the transformer; there is generally in alternating circuits another E. M. F. due to self-inductance on the line or n the apparatus connected with it. The current in the circuit is governed by the resultant of the two or more E. M. F.'s acting, and not to the line E. M. F. alone. The other E. M. F.'s are practically never in exact step (that is, in the same phase) with the line E. M. F., and therefore the resultant E. M. F. may have a considerable value at an instant when the line E. M. F. is zero. For example, suppose that the lines in Fig. 2 marked "Line E. M. F." and "C. E. M. F." represents to any convenient scale the mean values of the E. M. F. on the line, and the E. M. F. due to self-inductance (sometimes called the counter-electromotive force, or C. E. M. F.), and let the angle between them represent the angle between corresponding maximum values of these quantities. These two E. M. F.'s may be combined and their resultant found by the method explained in the Cathechism in AMERICAN ELECTRICIAN for October, page 412. The resultant of the two E. M. F.'s gives what is sometimes called the "active" E. M. F. which is effective in causing the current. The relation between the instantaneous values of the two E. M. F.'s and the resulting current are shown in Fig. 3, the current at any instant being due to the algebraic sum of the two E. M. F.'s at that instant, values above the horizontal base line being considered as positive and those below as negative. The above example is taken as a comparatively simple case, there being frequently more than two E. M. F.'s in practice. This example shows in an elementary way how the current may have a considerable value at an instant when the E. M. F. on the line is zero. Fig. 2 is drawn to represent a case in which the line E. M. F. is 100, E. M. F. of self-induction is 60 and current (or active E. M. F. causing current) is 80. The current lags behind the E. M. F. by about 34 degs. and the E. M. F. of self-induction is 90 degs. further behind. When the two E. M. Fs. are equal as at *A A* in the figure, the resultant E. M. F. is zero and the current is also zero. When the E. M. F. of self-induction is zero, as at *B B*, the resultant E. M. F. equals the line current and the current is caused by the line E. M. F. alone When the line E. M. F. is zero, as at *D D*, the resultant E. M. F. equals the E. M. F. of self-induction and the current is caused by it alone. When both E. M. Fs. are in the same direction, as at *C C*, the resultant equals their sum.

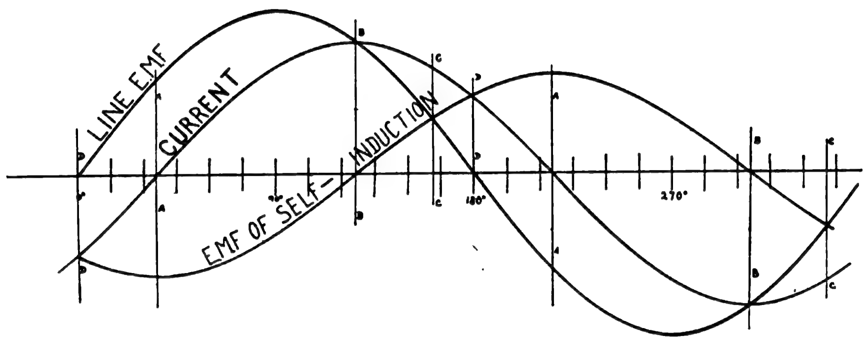


FIG. 2.—CURVES OF CURRENT, LINE AND INDUCTIVE E. M F.

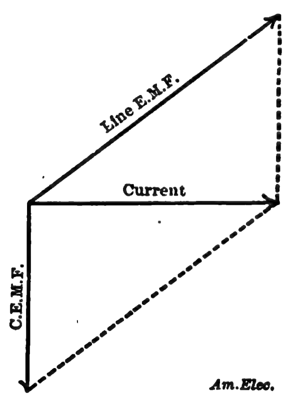


FIG. 3.—DIAGRAM OF E. M. F'S.

177. How can the C. E. M. F. or E. M. F. of self-induction be measured?

It cannot be measured, but may be calculated from the triangle of E. M. F.'s when the line E. M. F., current, resistance, frequency, lag and coefficient of self-induction are known. In simple cases, only the line E. M. F., current and angle of lag need be known.

QUERIES AND ANSWERS

Can the rating of a fuse wire be estimated from its gauge? N. D.

No. A 45-ampere fuse of one maker may be larger in diameter than a 60 ampere fuse of another.

Please give the detailed design of a 50-volt primary, 4-volt secondary, 5-KW transformer. C. M.

As such a transformer would give 1250 amperes in the secondary circuit, its construction would be very expensive, and its design a matter for a transformer specialist.

How may an exhausted chloride of silver battery be restored? C. L. B.

By sending a current through it opposite in direction to that of the current normally given by the battery. The re-charging current should be small, its value in a given case depending upon the size of a cell of the battery.

What would be the general principles upon which a telephone receiver might be constructed for amplifying sound? O. F. L.

If such principles were known, we would probably now have telephone repeaters, which subject is one that has engaged much thought and upon which thus far all inventors have failed.

What are some methods to make a dynamo "pick up" when no exciting current is available? W. H. B.

Try reversing connections between brushes and field windings. If this does no good, speed up the machine as much above normal speed as possible, with the field circuit *open* and all resistance cut out; then close the field circuit. Try this with present connections and reversed as above.

1°. I have a 125-volt, 220-ampere machine, and wish to get a reading of 250 amperes on an ammeter. What is a practical way of doing this, and will the extra 30 amperes overheat the winding? 2°. What fixes the KW rating of a machine at different voltages? M.

1°. Use a water rheostat connected to the main switch terminals, the latter being open; 30 amperes excess will do no harm if not maintained too long. 2°. The ampere capacity of the armature, which, of course, is the same at 5 or 125 volts.

1°. What size rhetostat should be used on a 500-volt circuit in order to run from it a 110-volt fan motor, small diagnostic lamps, cautery for surgical purposes, etc.? 2°. What capacity of motor is required to run the influence machine shown on page 108, March issue? H. L.

1°. Use incandescent lamps for resistance, five 100-volt lamps in series for each $\frac{6}{10}$ ampere required. If the circuit is a grounded railway circuit, insurance rules prohibit a connection from it leading it into a house. 2°. A ¼-HP motor will be sufficiently large, the speed being geared down. Try a large fan motor.

How can I make an electrical thermostat? C. G. W.

A mercury thermostat for indicating a maximum temperature may be made by connecting one end of a battery circuit to an iron cap containing mercury, the other end connecting to a wire projecting into a glass tube of small diameter dipping into the mercury; as the temperature increases, the mercury in the tube will rise and complete the circuit when it comes into contact with the end of the wire projecting in the tube. Another form may be made by riveting together two long strips of brass and iron, or brass and india rubber, and coiling into a spiral. As the temperature changes, the spiral contracts or expands, and a projecting piece from the inner end may be arranged to make contact with one or another of two contacts between which it plays.

What are the charges in New York for current from the Edison mains? J. H. B.

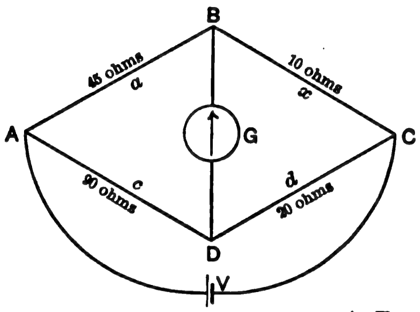
Small consumers pay one cent per incandescent lamp-hour, equivalent to about twenty cents per KW-hour, with a minimum charge of $1.50 monthly. Discounts are given on bills, graded from 5 per cent. for $100 per month to 40 per cent. for $1000 per month or over; those using 5000 or more incandescent lamp-hours per month are given an additional discount of 5 per cent. on two hours per day average use of the installation, 10 per cent. for three hours, 15 per cent. for four hours and 20 per cent. for five hours. For 480-watt arc lamps the charge is ten cents per lamp-hour, with discounts graded from 10 per cent. for 100 lamp-hours per month to 35 per cent. for 1000 lamp-hours or over, there being a minimum charge of $3 per month for each lamp connected; on the gross bill an additional discount is allowed of 5, 10 and 15 per cent. for monthly lamp-hours of 100, 150 and 200 or more, respectively. For motor service the charge is ten cents per HP-hour, with discounts graded from 20 per cent. for 100 HP-hours per month to 50 per cent. for 1500 HP-hours and 55 per cent. for 5000 HP-hours. For light and power service of large buildings not using less than 2500 KW-hours per month, and with an average use of not less than two hours daily, the charge is ten cents per KW-hour, including the supply of arc and incandescent lamps, and trimming of the latter; for average uses of 4, 6 and 8 hours daily, there are discounts of 10, 20 and 30 per cent., respectively, and a discount of 5 per cent. for 5000 KW-hours monthly, and 20 per cent for 10,000 KW-hours monthly.

1°. In the case of two or more compound-wound generators operating in parallel circuit, how low may the voltage in any machine drop before it will reverse and run as a motor? 2°. Is the load divided among the generators in inverse proportion to the resistance of the armature and field circuits of each, the voltage being uniform? 3°. Authorities assert that electrical energy does not flow along the substance of a conductor, but is transmitted across the surrounding medium transversely; how can this be true in view of the fact that the resistance of a conductor does not vary inversely as the surface curve? A. S.

1°. This depends upon the resistance of the connections between each machine, the common bus-bar and the armature windings, so that the margin is usually very small. When the E. M. F. of one machine exceeds that of its mate by a voltage sufficient to force half the amperes supplied by both through the intervening connections, the "balance point" is located at the brushes of the latter machine, and any further increase in E. M. F. from the storage machine will cause current to "back through" the armature of the weaker and make a motor of it; this will not reverse its direction of rotation, but will cause it to run faster. 2°. The voltage being absolutely uniform, the load is divided among the generators in proportion to the resistances of the various armature circuits, reckoning from the bus-bar through the armature windings. The resistance of the shunt field windings has no bearing on the division of the load. See p. 12, January issue for article on the "Equalizer." 3°. You have confused current with electrical energy, and the conventional with the etherial theories of electricity. The subject is too large a one to be taken up here. See Lodge's "Modern Views of Electricity," or Trowbridge's "What is Electricity."

What is the principle of the Wheatstone bridge? C. H.

To better fix ideas, we will take electric light currents and voltage, as indicated in sketch. By Ohm's law, $C = \frac{E}{R}$, the current

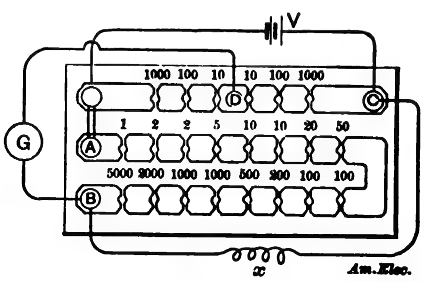


110 volts Am. Elec.

in ABD is $110 \div 55 = 2$ amperes; in AeD, $110 \div 110 = 1$ ampere. The drop ($E = CR$) from A to B is $2 \times 45 = 90$ volts; from A to C, $1 \times 90 = 90$ volts. Therefore, the drops to B and C being the same, the potentials at those points will be equal, and no current will flow through the galvanometer, G. That is, when $a \times d = c \times x$, the bridge is balanced. This may be expressed,

$$x = \frac{d}{c} \times a.$$

In practice, the resistances of the two wires, c and d, are fixed in a certain ratio for a given measurement (in this case, 20 : 90, but usually as 10 : 100 or a multiple of 10), and the value of a varied until a balance is obtained. A commercial Wheatstone bridge



is shown herewith, with the parts lettered to correspond to the above, x being the resistance under measurement. In this case, c is the left part of the upper row, d the right part, and the two lower rows correspond to a. If c were plugged for 1000, and d for 10, and if 1425 plugged in b brought a balance, then the value of x would be 14.25 ohms.

New Apparatus and Appliances.

PORTABLE MILLI-AMMETERS FOR ALTERNATING CURRENT CIRCUITS.

We are in receipt of a communication from the Keystone Electrical Instrument Company, of Philadelphia, in which they announce the above novel instrument. They state that something over a year ago they received a request from the Committee on Meters of the American Electro-Therapeutic Association to design and submit for test a portable milli-ammeter for use on the sinusoidal alternating and Faradic current circuits. The solution of the voltmeter problem was quite simple, and the requirements were fully met by their portable voltmeter for direct and alternating current circuits, but the design of a portable milli-ammeter for this class of work presented a very novel problem which had never been successfully solved.

After several months careful experimenting they succeeded in perfecting an instrument which practical test proved to be eminently satisfactory. The report of the Committee on Meters presented at the annual convention of the American Electro-Therapeutic Association, held in Harrisburg last September, contained an unqualified approval of this instrument, and as the result of their tests and investigation, recommended them to the profession. In the course of the experimental work a number of tests were made with the milli-ammeter and some data obtained on commercial apparatus which heretofore had only been obtainable by calculations.

Among other things tested was the current consumption in the primary coils of transformers when the secondary was on open circuit, thus determining directly and without calculation the idle losses in the transformer system. The result of the test showed the very great difference in what might be termed the idle efficiency of transformers of various makes, and further showed a marked difference between new transformers and transformers in which the iron had aged as the result of several years continuous use.

This whole question is one of more than passing interest to central station managers who employ the alternating current, and careful tests of the amount of current required to energize the primary coils of transformers when the secondary is in open circuit would, no doubt, lead to a more careful selection of transformers and the replacing of many which have outlived their usefulness. Direct reading in such matters is far superior to calculation, and we have no doubt that many stations would discover unexpected losses by making a series of tests on the transformers now on their lines.

The instrument itself is neatly designed and mounted in a polished mahogany case, its calibration is carefully made and its indications may be relied upon as perfectly correct.

ELECTRICALLY-DRIVEN FLOUR MILLS.

Since the completion of the great three-phase electric power transmissions on the Pacific Coast, between Folsom and Sacramento and the San Joaquin and Fresno, the use of electricity as a motive power has made great strides. Two of the most important flour mills are now added to the already long list of consumers.

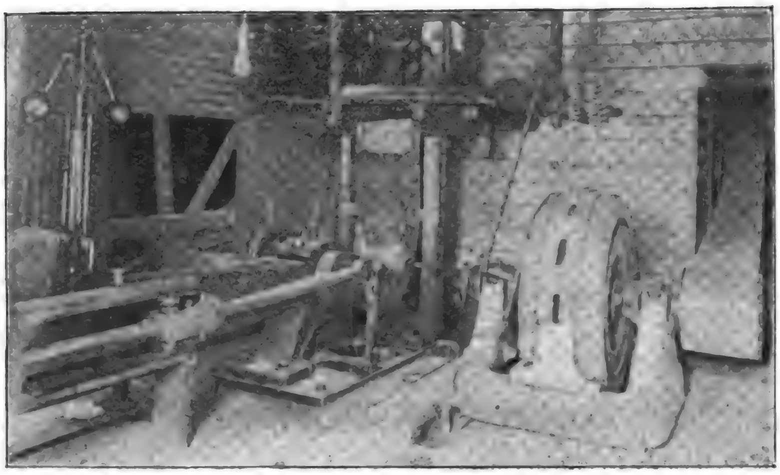


FIG. 2.—75-HP INDUCTION MOTOR IN PHŒNIX FLOUR MILL.

The first to place its dependence on electric motors, instead of the steam engine, was the Sperry Flour Mill, of Fresno. This is driven by a General Electric synchronous motor, of 150-KW capacity, running at 600 revolutions. Fig. 1 shows this motor with a small bipolar motor to bring it up to speed; both are in the basement of the mill, whence the main belt passes to the rolling and grinding machinery above.

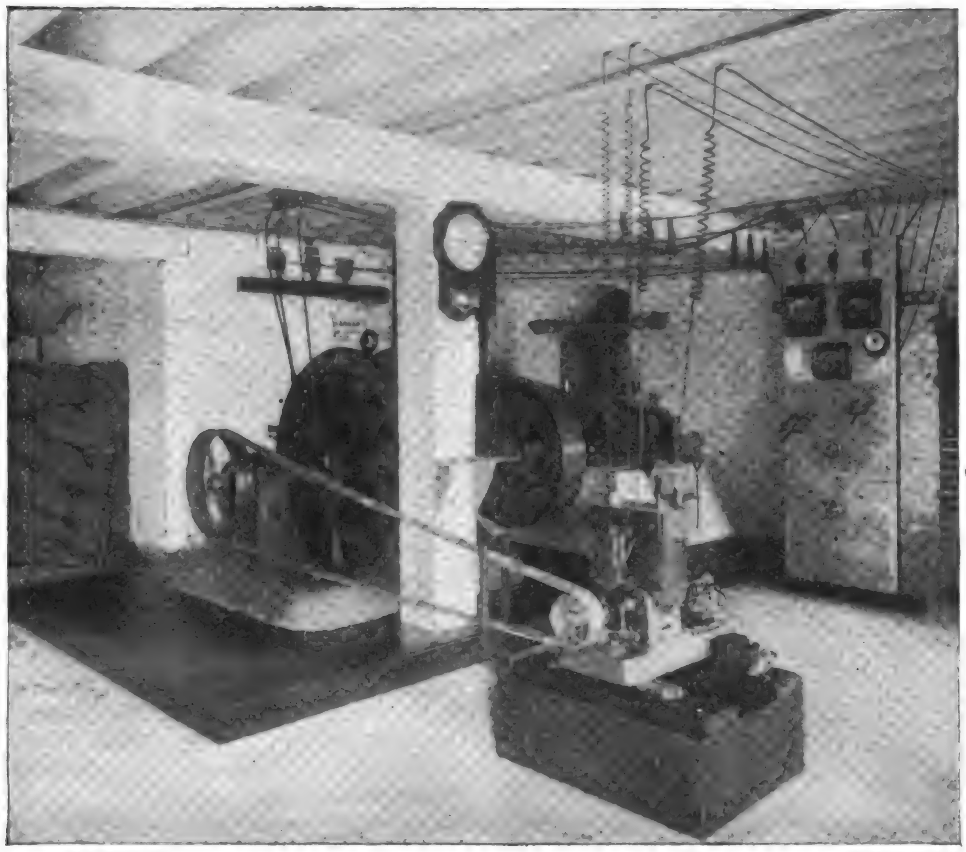


FIG. 1.—150-KW SYNCHRONOUS MOTOR IN SPERRY FLOUR MILL.

The second mill is the second in importance on the Pacific Coast, and the largest flour mill in the United States using electricity instead of steam. Its electrical equipment consists of three General Electric three-phase alternating-current induction motors, operating at a pressure of 500 volts. The largest of the three motors has a capacity of 75 HP. This (Fig. 2) is belted to the main shaft of the mill, and drives all the flour-making machinery. It runs continuously for twenty-four hours, and for three months without stop. The second largest motor is one of 30 HP. This occupies a position on the second floor of the mill, and drives all the cleaning machinery. It runs continuously for eighteen hours daily. The third is a 20-HP motor, and is placed in the basement near the 75-HP motor. This drives the roll for grinding the corn and the barley. Its work is intermittent, and it runs from eight to ten hours per day only.

The power consumed by the motors is registered by means of recording meters which show the total horse-power of current consumed. These meters register exactly the power used and allow the company to keep a careful watch upon their machinery, and obtain the highest economy in operation. For instance, when the cleaning for the day is completed, and the 30-HP motor and all the cleaning machinery are shut down, all expenses for power in that department cease at once. No power is wasted in running idle shafting and belting. The same is true in a still greater degree in the corn and barley crushing department, where the work is more intermittent.

The motors are so simple in their operation that any employe about the mill can handle them. To start the motor a simple switch is closed and a lever on the motor thrown over. In less than a minute the motor begins to perform its full load of work and continues without further attention from the operator. The stoppage of the motor is an equally simple process. No attention is required beyond this, except that entailed in keeping the motor lubricated. It is estimated that the economy in actual power consumed in the Phœnix Mill by the present method of driving is not less than 15 per cent, and the total saving in the entire cost of operation will pay for the electric motors, their installation and adaptation in less than one year.

THE RICHMOND PLUG CUT-OUT PANEL BOARD

The type of plug cut-out panel board illustrated herewith is a radical departure from any now on the market, and is claimed to combine the best features of panel boards and plug cut-outs. The board is especially designed for cut-out cabinets, but can be used in exposed places with less

FIG. 1.—PLUG CUT-OUT PANEL BOARD.

danger than porcelain blocks, as there is no hazard from melted fuse metal.

The sockets for the plugs are formed in the slate or marble base, as shown in the cut, and the plug screws directly into the bus-bars placed on the back. The connection to the branch circuits is made upon the front of the board by means of circular castings, while the fuse is carried by the plug connecting the front casting to the bus-bar. By this construction a fuse is used capable of being used on a 220-volt system without danger of arcing. In addition, the fuse metal cannot blow out against the hand, as in the case in plugs with vented caps.

The plugs are made of porcelain in one piece, and can readily be re-fused, as with these boards it is not necessary to open a circuit switch to re-fuse a circuit—an advantage

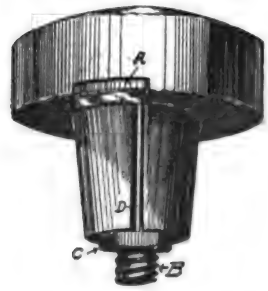


FIG. 2.—CONSTRUCTION OF PLUG.

which the station manager and electrician will appreciate.

Fig. 2 shows the construction of the plug. The square headed bolt, *B*, passes through the center of the plug and is held in position by the lock-nut *C*. When *B* is screwed into the threaded hole in the bus-bar, as seen in Fig. 1, the terminal piece, *A*, is brought in contact with the circular casting on the front of the board, thereby completing the circuit through the fuse, *D*. It can be re-fused by removing the lock-nut, *C*, and contact, *A*.

The cut shows a four-circuit board with two plugs in position, arranged with one switch. The boards are being made in sizes from four circuits up, with or without switches, for use on two or three wire systems. The circuits are arranged as desired, across the board, for both polarities on one side for single or twin-wire system.

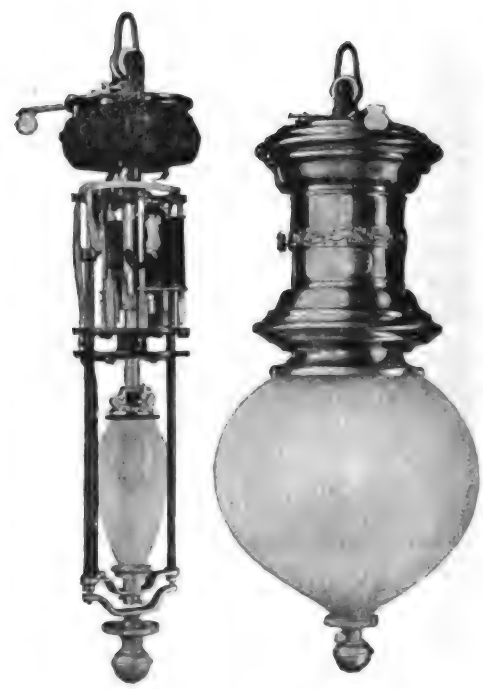
A patent has been secured on the board described by F. S. Richmond, Chicago.

ENCLOSED ALTERNATING-CURRENT ARC LAMP.

Perhaps the most objectionable feature of such alternating-current enclosed arc lamps as have heretofore been placed on the market have been their too low economy and noisy, uncertain action. In the new alternating-current arc lamp, manufactured by the General Electric Company, these characteristics are claimed to be overcome. It operates on constant-potential alternating circuits with higher economy and greatly diminished noise. The principles of the enclosed arc lamp and the economical advantages of its use over open arc lamps are familiar to our readers, but as between open and enclosed alternating arc lamps, it is not so generally known that a greater difference in economy in favor of the enclosed lamp is shown than in the same comparison between open and enclosed direct current arc lamps. In the G. E. alternating-current enclosed arc lamp, one pair of carbons will last between sixty and seventy hours, and give a saving of about 80 per cent. in the cost of lamp carbons; a larger arc is maintained; the light is emitted without obstruction; and its protection from currents of air and any sudden action of the mechanism allows the light to become and remain steady.

The mechanism is simple, the number of moving parts being reduced to a minimum, and its action is quick and positive. A special adjusting spring keeps the current constant whatever the position of the core. The mechanism is supported on a frame with a double base which gives a dead air space and provides protection for the mechanism from the heat of the arc.

This lamp operates on circuits of 100 to 120 volts and 60 or 125 cycles frequency, About 70 volts are required at the terminals of the arc, and the normal current being 5.5 to 6 amperes. An inductive resistance contained within the ornamental top of the lamp, and connected in series with the arc, gives the necessary reduction in the voltage, and preventing sudden changes in current, checks any unsteadiness of the light. The half inch carbons used are 9½ ins. long in the upper holder and 6 ins. in the lower—one cored, the other solid, and they must, of course, be of high grade. They are proportioned to allow the piece left in the upper holder after one run, to be used in the lower holder for the next. The inner globe is supported by a self-locking device. To



ALTERNATING CURRENT ENCLOSED ARC LAMP.

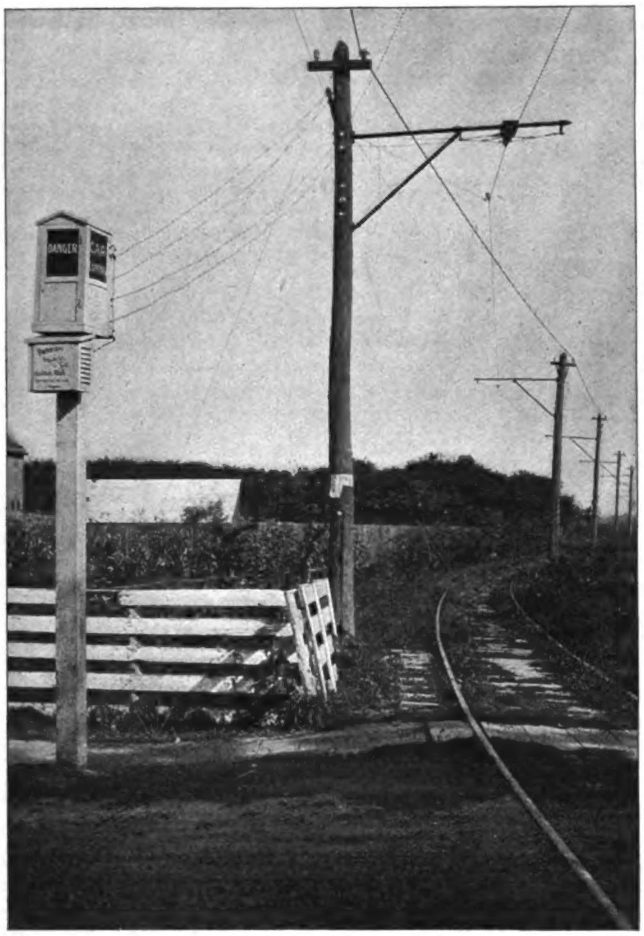
lower the globe, the lower ball is unscrewed, the globe raised slightly and released by turning the release screws on the side of the cylinder. To replace it, the globe is simply raised until it locks, when it is tightened by screwing up the lower ball.

The General Electric alternating-current enclosed arc lamp is 28¼ ins. in length and 31½ lbs. in weight. It is artistic in its proportions and is judiciously ornamented. For interior illumination, *i.e.*, for halls, large stores, restaurants, theatres, public buildings, the casing of the lamp is finished in ground brass or black enamel; for outside use a weather-proof casing is furnished.

RAILWAY CROSSING SIGNALS.

The problem of crossing protection is every day coming more and more to the front in the efficient operation of electric roads where speed and safety are required. The question of crossing accidents and the resulting endless claims for damages is a most important one to railroad managers. The Parrish electric railway crossing signal is a new device designed to provide such protection at grade crossings. It has but lately been put upon the market after tests covering a period of nearly two years.

In construction and operation the signal is very simple. It is a system in which both lights and bell are used, located at the crossing to be protected and controlled by a relay connected electrically with three switch boxes placed above the trolley wire, one each side of the crossing some distance away starting the signal, and one at the crossing stopping it. When desired, connection can also be made to the track. The construction of relay and switch boxes which, with bell and lights, constitute the signal, is so simple as to require scarcely any attention. It can also be relied upon to work in all kinds of weather, not being affected by rain, snow, sleet or intense cold. The signal is automatically operated by the car approaching the crossing, which causes the ringing of a bell and the flashing of a red light, continuing until cut out at the crossing. The same operation holds good for cars moving in either direction on single or double track. In the latter case the alarm is given until the last car is past the crossing. Its reliability, simplicity and durability, together with the absolute certainty to give the signals named, are strongly emphasized. The original cost is not great, while the annual expense for power and maintenance is practically nothing.



RAILWAY CROSSING SIGNAL.

The uses for which the signal are adapted are many. It not only affords protection against crossing accidents, but also, while giving a danger signal to the public, shows crossing clearance to the motorman, enabling increased speed with greater safety and insuring higher earning capacity per car. It can be used upon either overhead or underground trolley, or third rail system, and also as signals for motormen, for stations, for block signal work upon main line, turnouts, or grade crossings with other lines, and it is especially applicable for drawbridge protection. The signal given in the illustration is in use upon the Glen Haven & Irondequoit Electric Railroad at Rochester, N. Y. It is also in operation upon electric and steam roads in different parts of the country. The signal is manufactured by the Parrish Signal Company, Jackson, Mich.

TIME SWITCHES.

A device for automatically turning off and on the lights in a store has recently been perfected. This is called an automatic time switch. The Western Electric Company, of Chicago and New York, are the agents for the United States.

This switch is a double pole, 30 ampere, snap switch, with a capacity up to 220-volts arranged in combination with a clock. Any person desiring his lights to burn until 12-00 o'clock, or any specified time, sets the clock as he would an alarm clock, and turns on the lights. As soon as the time indicated by the little pointer on the dial of the clock is reached the clock automatically releases a catch and the lights are turned out. The same device is used for turning on lights.

Where central stations are selling light by contract to burn to specified hours these automatic time switches can be installed by the electric light company and the inspector carry a key to the switch. By this means the company can be assured of having the light turned off at the time specified in their contracts with customers. If the customer has a meter and desires to keep his store illuminated until a certain hour he can with perfect assurance lock his door and leave the automatic switch to take care of the lights, knowing that he is not dependent upon the service of any watchman, and that his lights will not be taking current and a bill run up on account of lack of attention.

PERSONAL.

Mr. Nelson W. Perry has resigned the editorship of *Electricity* to accept a position with Westinghouse, Church, Kerr & Company, and the Westinghouse Machine Company. While one of the most capable writers on electrical subjects and one of the very few technical writers possessed of a graceful literary style, Mr. Perry is also an engineer by education, and with a wide experience in practical work. In his new field he will carry with him the best wishes of a host of friends.

Mr. William Henry Cothern's many friends in electrical circles will learn with surprise and deep regret of his death from consumption, which occurred at Phoenix, Arizona, November 11. Graduated with high honors from Bowdoin College in 1884, he remained two years as an instructor in physics and chemistry, which position he resigned to become superintendent of construction for New York Edison Illuminating Company. Subsequently he was assistant manager of the central district of the Edison General Electric Company, at Chicago, and in 1892 accepted the position of assistant general manager of the Cincinnati Illuminating Company, from which he retired on account of the progress of the disease from which he died.

NEW BOOKS.

PRACTICAL ELECTRICAL MEASUREMENTS. An Introductory Manual for Young Engine rs and Students. By Ellis H. Crapper. New York: The Macmillan Company. 125 pages, 56 illustrations. Price, 75 cents.

While the primary object of this work is educational rather than electro-technical instruction, it will nevertheless be found useful by electricians who always read with a practical end in view. The theory of the Wheatstone bridge is very fully treated, as is that of the galvanometer. The book is given a direct practical value by the numerous exercises included, both numerical and descriptive.

ELEMENTS OF THE DIFFERENTIAL AND INTEGRAL CALCULUS. With Applications. By William S. Hall, C. E., M. S. New Y rk: D. Van Nostrand Company. 249 pages. I ric , $2 25.

This work is an in roductic n to t e study of the differential and integral calculus, and intended for colleges and technical schools. The treatment is entirely academic, and as the book is for class work, its development of principles is tco summary for the self-teaching student. An excellen feature of the work, which will be a preciated by those who have forgotten integrating processes, is a dozen pages of integral forms, numbering 156 in all.

AMERICAN AND OTHER MACHINERY ABROAD. By Fred J. Miller. New York: American Machinist. 90 pages. Price, 50 cents.

The substance of this book was written in the form of letters to the *American Machinist* during a trip abroad of the editor of that journal. These letters attracted much attention at the time of their appearance, giving as they did a comprehensive review of the situation with respect to the field for Ame ican machinery abroad. In this respect the book will interest every manufacturer seeking a foreign market, either directly in pointing out opportunities existing, or indirectly through the information it conveys as to the conditions to be met, both technical and commercial.

GAS, GASOLENE AND OIL VAPOR ENGINES. By Gardner D. Hiscox, M. E. New York: Norman W. Henley & Company. 279 pages, 206 illustrations. Price, $2.50.

Should this work direct reater attention to the advantage of explosive motors, it will have performed a good office, as the United States labors under the reproach that it has been far outdistanced by Europeans in the employment of this type of heat engine. While several chapters are devoted to the theory of the gas and gasolene engines, the book is essentially descriptive and practical in its plan. All of the various important types of motors of American manufacture are described and illustrated, and chapters given on management, measurement of power and testing. The recent types of gasolene engines for vehicle propulsion are described, and also those employed in the propulsion of boats. To those who desire to look up American practice in this field, this book will be indispensable.

TRADE PUBLICATIONS.

A Pocket Convenience. The Pettingell-Andrews Company, Boston, is distributing among its friends a neat morocco pocket case made to contain a copy of the "National Electrical Code," the new code of underwriters' electrical inspection rules.

Gears. The Cleveland Gear Works, Cleveland, O., in a recent catalogue describes and illustrates a large variety of gears, racks and pinions, including worm and spiral gears. An instructive feature of the pamphlet is an article on the drawing of a spur gear wheel.

Art in Advertising. The Western Electric Company is mailing to its customers a very handsome picture of a lion which is a reproduction from nature. This picture is a half-tone printed upon a cardboard 11 ins. × 14 ins. with a silk cord at the top for hanging.

Engineering Specialties. The D'Este & Seeley Company, 29 Haverhill Street, Boston in a new edition of their catalogues describe and illustrate the numerous Curtis steam specialties, which include pressure regulators, steam traps, damper regulators, separators, temperature regulators, feed regulators, etc.

Pumps. The new catalogue of the Deane Steam Pump Company, Holyoke, Mass., contains 133 pages and at least half as many illustrations. The machines illustrated cover the entire steam pumping field—from 3 ins. x 2 ins. boiler pumps to marine type, vertical triple-expansion condensing fly-wheel engines, driving water works pumps.

Coal and Ash Conveyors. The Link Belt Engineering Company, Nicetown, Pa., has issued a booklet luxuriously bound in leather, describing and illustrating the Link Belt carrier. The many illustrations with accompanying explanations give a thorough understanding of modern methods of ash and coal conveying. This little book will be of particular interest to central station and power house managers.

X-Ray Apparatus. James G. Biddle, Drexel Building, Philadelphia, has issued a handsomely printed pamphlet entitled "Concerning X-Ray Apparatus." From the extent of information of general value contained, this pamphlet deserves to be ranked among technical treatises on the subject considered. Among other recent trade literature from the same source are a monograph on the Rosa curve tracer, and two catalogues of electrical measuring apparatus.

BUSINESS NEWS.

Large Orders. The General Electric Company during the months of June, July and August received orders for 278 generators, aggregating nearly 14,000 K. W. for lighting purposes alone.

Large Addition to a Plant. The installation of the People's Light & Power Company, of Newark, N. J., will shortly be increased by eighteen 125 light Brush arc dynamos, having a total capacity of 2250 2000-CP. arc lamps.

Carbon Battery. The name "Economy," which the Western Electric Company has adopted for their specially prepared carbon battery, has become well-known among contractors owing to the efficiency of the battery.

Enclosed Arc Lamp. The Western Electric Company is placing upon the market an ornamental enclosed arc lamp similar in style to their standard enclosed arc lamp, but finished in polished brass. The features of this enclosed arc lamp have placed it in the front rank.

Bicycle Electric Light. The Ohio Electric Works, Cleveland, O., is receiving many flattering testimonials concerning its three and four cell bicycle electric light outfits. These lights cannot be jolted, throw a light 200 ft., and will run four hours on a charge costing but a few cents.

Small motors. Soldmark & Wallace, 5 Reade Street, New York, are making a specialty of small motors of from 1/6 HP to 10 HP, and have built up an enviable trade in motors of these sizes. They carry in stock a very complete assortment and are prepared to make immediate shipments.

Non-Sparking Brush. The Western Electric non-sparking brush, which is manufactured by the Western Electric Company, is made under a patent granted to Dr. Ludwig Gutman, the well-known electrical engineer, and is composed of a composition of high and low resistance metals.

Wm. E. Kline & Company, 125 Liberty Street, New York, is a new electrical supply house located at the above address. Messrs. Wm. E. Kline and Wallace J. Lester are the partners in the new company, which will handle incandescent lamps, making a speciality of miniature and surgical lamps.

Norwegian Mica. The Norwegian Mica Company has been recently organized, with offices in Christiana, Norway, and will work mines of mica in Norway. The board of directors are the professor of mineralogy at the University of Christiana Yohan, H. L. Vogt, and a well known civil engineer in Christiana, Mr. Henry E. Mohn, the latter as president.

Marine Type Generating Set. The Thresher Electric Company, Dayton, O., has its shops filled with work, with many orders awaiting their turn. Among recent apparatus meeting with much success is a marine type of generating set, which is a model of compactness. It will repay sending for a circular descriptive of this and several other recent apparatus

Home Electrical Instruction. *The United Correspondence School*, 154-158 Fifth Avenue, New York, include a comprehensive course in electrical engineering, and special courses in electrical station engineering for employes of electric light and power stations. By addressing as above an illustrated circular may be obtained giving full information as to methods and courses.

Chicago Horse Show. The B. F. Chase Company, the well-known sign makers, were the fortunate contr ctors who secured all the illuminated sign work for the famous Horse Show held in Chicago. They used exclusively the Sunbeam incandescent lamp, a number of them being the special 4 CP lamps designed especially for sign work. The Western Electric Company is agent for this lamp.

Periods when to Make Money. Those who believe that periods of panic recur in cycles will be interested in a card issued by Geo. W. Patterson, 1114 Dearborn Street, Chicago, a copy of which may be obtained upon application. The card contains a diagram showing that since 1816 the cycles of hard times have occurred at intervals of 9, 7 and 11 years, and that 1897 is the beginning of a period of prosperity.

The Emerson Electric Company, St. Louis, is just closing a prosperous year, having had a very large demand for the general line of supplies it manufactures. The demand, so it states, has been especially large for standard switches, cut-outs, switchboards, etc. As regards fan motor output, it reports that it has not stopped work in this line at all, but is working steadily on '98 orders. A new and complete catalogue has just been issued which describes and illustrates the various manufactures of the company.

Nashville Exposition Award. The American Electric Telephone Company, of 171 South Canal Street, Chicago, was the most successful competitor in the section of telephony at the Tennessee Centennial Exposition, which has just closed, receiving the highest award for meritorious apparatus in the way of telephones and switchboards. The American Company's success at Nashville follows up in a most satisfactory manner the previous successful competition at Atlanta, at which exposition it also received the highest award.

Electric Light Fixtures. The Western Electric Company, Chicago, has furnished a room, 18 ft. × 18 ft., in the rear of its store as a show room for fixtures. Numerous chandeliers and brackets have been placed in this room and these have been wired up with 2-point, 3-point, 4-point and combination switches in order to show the methods by which lights in private houses may be controlled. A large variety of beautiful shades is shown on the fixtures. Five of the Western Electric enclosed arc lamps are also exhibited.

Diemer & Hebble have opened an office in the Neave Building, Cincinnati, as electrical contractors. Mr. Hugo Diemer, the senior member, was until recently purchasing agent for the Bullock Electric Manufacturing Company; the junior member, Mr. C. R. Hebble, was formerly engaged in business in Xenia, O. They will represent in their territory the Card Electric Company, of Mansfield, O., and the Shelby incandescent lamp. As both the gentlemen named are graduates from technical institutions, and have had practical, as well as live business experience, their prospects of securing a fair share of business in their territory are bright.

Enclosed Arc Lamps. The enclosed arc lamp is recognized to-day as the only arc lamp, and the business has grown to such magnitude that the Electric Arc Light Company early in the season took steps to enlarge its manufacturing plant, which is now completed, with a capacity of 1000 lamps per month. With the new facilities thus secured, and with the large amount of business being done, the company has been enabled to effect a saving and announces considerable reduction in price of its Standard brass lamp. Now that the commercial position of the Pioneer lamp is assured, it is understood that the owners of the Marks patents are about to begin a vigorous crusade against all infringers.

Electric Turn-tables. The Baltimore & Ohio Southwestern Railway has been experimenting with electric motors on turn-tables. Turning locomotives at divisional points and terminals is a service of much annoyance and no little expense to railroad companies. It generally takes four men to turn a locomotive, and while they are doing so their regular work is abandoned. Experiments were made with an electric motor on the 60-ft. turn-table at Chillicothe with such success that the Park Street turn-table at Cincinnati was similarly equipped. The result has been rather astonishing in the matter of expense. The current was purchased from the power plant and it cost on an average of less than one-half a cent for each time the table was turned. When this same table was operated by hand it cost 12 cents for each engine. The yearly saving is about $709.

Increase in Western Business. Roth Brothers & Company, 28-30 Market Street, Chicago, report their plant running at its fullest capacity, and have recently been compelled to put on a larger force of operators. They have also added largely to their factory equipment in the past month, in the way of new and improved dies, presses, lathes, etc. Their equipment is now so complete that they are enabled to fill their orders with even greater dispatch than heretofore. For enterprise and general hustling qualities, coupled with an output of strictly first class goods, Roth Brothers & Company stand among the foremost in their line. They recently issued a new eight-page circular, describing and illustrating some twenty-four different types of their apparatus. This is a valuable circular and should be in the hands of every buyer.

American Machinery in Russia. The Ball Engine Company, of Erie, Pa., is in receipt of the following letter from Julian Kennedy, the eminent steel works engineer, of Pittsburgh, which refers to a 400-HP vertical engine, direct connected to a Siemens-Halske generator: "I am in receipt of a letter from Mr. H. S. Loud, general manager of the Nicopol-Maripol Mining & Metallurgical Company's works in South Russia, in which among other things he says: 'The electric plant is working beautifully. You would be doing an almost obligatory service in thanking both the Siemens-Halske and the Ball Engine people for me for the very great satisfaction which their machinery has given this company. The Ball Engine people were especially gracious in the prints, etc., sent, and their workmanship is magnificent.' I take pleasure in advising you of Mr. Loud's appreciation of your machinery."

Telephones. The Central Telephone & Electric Company, of St. Louis, has succeeded to the business of the D. A. Kusel Telephone Manufacturing Company. Mr. Jas. S. Cunning, the manager of the old company, will have full control of the new firm's policy, and by important improvements in the instruments has already established a greatly increased demand for its goods, having filled orders last week for complete exchange equipment at Baird, Tex., and also several long lines in Illinois, besides smaller orders from West Virginia, Georgia, Mississippi, Tennesee, Arkansas, Indian Territory, Kansas, Nebraska, Idaho, Iowa and Missouri. The progressive up-to-date policy of this company is rapidly winning recognition, and the outlook for business is bright. A revised price list is now being prepared which is promised to be the most complete of its character ever issued. A copy of the new catalogue will be mailed to any one on request mentioning this paper.